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Space/Aeronautics

THE MAGAZINE OF AEROSPACE TECHNOLOGIES

OCTOBER 1961

Materials for Solar-Energy Systems

- Maser R&D
- Solid-Propellant Gas Generators
- Thermal Factors in Equipment Design

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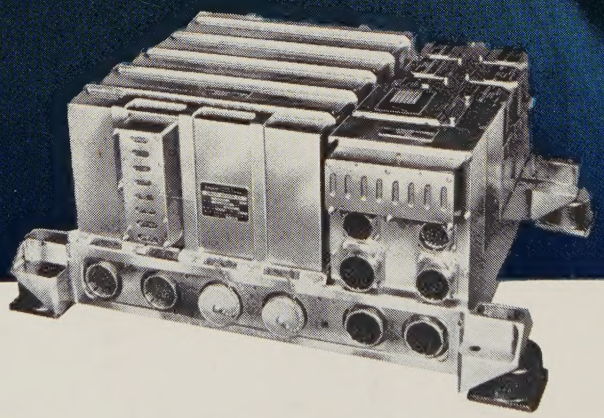

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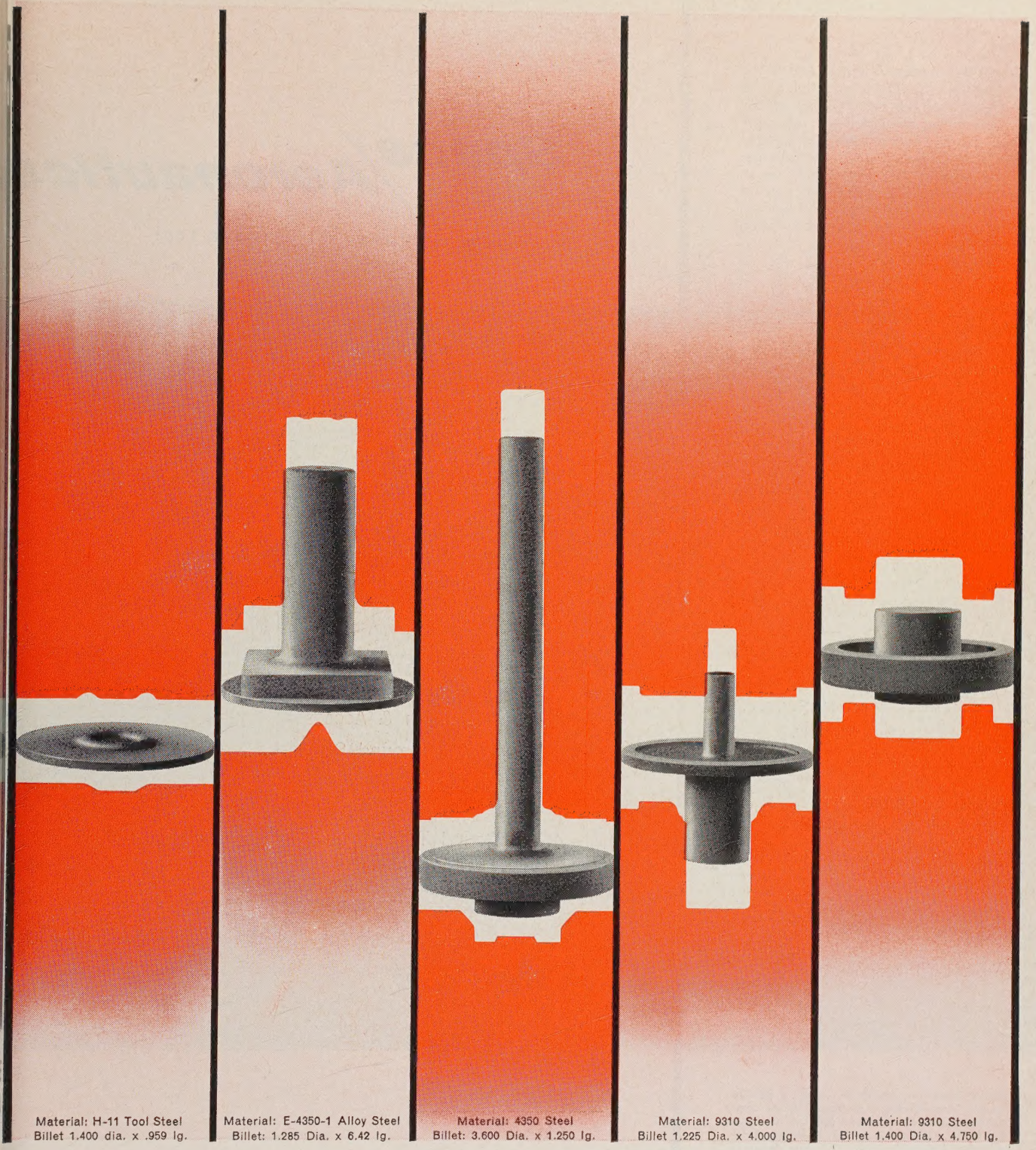
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Material: 4350 Steel
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Space/Aeronautics

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REPRINTS

In response to numerous inquiries, Space/Aeronautics is making available reprints of "Communications Satellites: The Technical Problems," a special S/A survey printed in the September issue, free of charge. If you missed reading this important and comprehensive article, or would like extra copies send your name, title, company, and address to:
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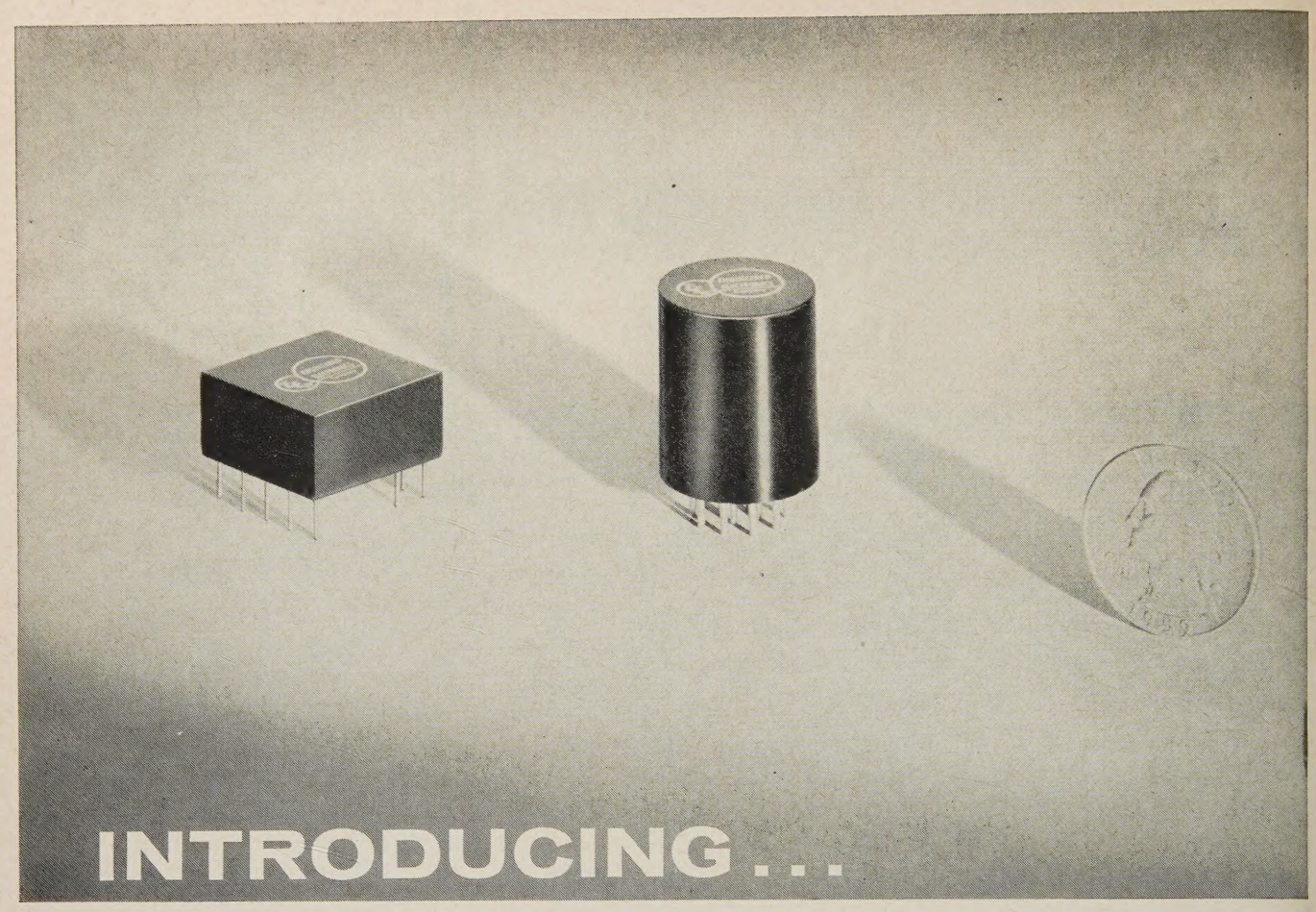
COMING

November will bring a bonus to S/A readers: a separately bound, full-size special report on ground support technology, in addition to the regular issue. The report will be in three parts. The first section is an alphabetized, quick-reference index to the GSE capabilities of every major company in the field, with the specialties of each graphically highlighted. Section two gives a listing-in-depth of each company's GSE experience, in the form of recent contracts, together with a rundown on areas of capability and special skills, and a list of GSE literature available from each firm. The third section is a detailed engineering analysis of GSE design trends, problems, plans and requirements. The areas covered include automatic checkout; range instrumentation and ground data processing; booster handling and nuclear support; launch monitoring and control; and in-flight space support. Military criticisms of present GSE designs and the needs of each service for the future are also reviewed.



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HOW WOULD YOU IMPLEMENT THIS EQUATION AT RATES UP TO 1 MEGACYCLE?

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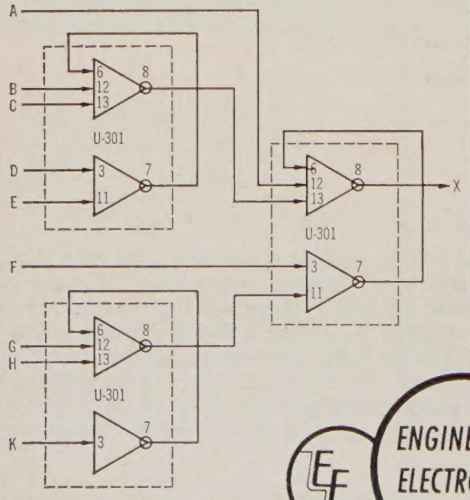

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abstracts

Management

NASA views our national space goals

Most NASA leaders believe that the scientific and technical benefits from our space program are its most important aspect, and that these benefits will extend well beyond the aerospace field. A minority, however, considers victory in the race to the moon more important than anything else.

by Randolph Hawthorne, editor

space/aeronautics 36/4 (Oct. '61) p. 52

Accessory Systems, Secondary Power

Solid-propellant gas generators

A state-of-the-art report on recent design advances, including reduction in flame temperatures, lower burning rates, and improved environmental stability. Discusses advantages of various generator configurations and solid propellants.

by B. M. Corley, Rocketdyne

space/aeronautics 36/4 (Oct. '61) p. 72

Dynamics, Structures, Systems Engineering

Re-entry systems outgrow conservative designs

Reviews the current state of re-entry body development, pointing out the drastic changes that re-entry bodies have undergone in their few years of existence. Ballistic and satellite re-entries are compared, and the shapes of lift-type re-entry vehicles are discussed.

by Lawrence D. Ely, Aerospace

space/aeronautics 36/4 (Oct. '61) p. 55

Testing, Electronics, Accessory Systems

Inertial test table is stable to 10^{-6} g

Detailed report on the design and performance of a test platform for the calibration of inertial-guidance components. The platform is designed to experience accelerations no greater than 10^{-6} g at frequencies from 0.2 to 200 cps.

by G. L. Neidhardt & F. T. Sasaki, American Machine & Foundry

space/aeronautics 36/4 (Oct. '61) p. 77

Materials, Accessory Systems, Secondary Power, Electronics

Materials for solar-energy systems

Analysis of the role of radiation and environmental characteristics in the application of materials in the conversion of, and in protection against, solar energy and survey of materials available under development for these applications.

by Roger E. Gaumer, Lockheed Missiles & Space

space/aeronautics 36/4 (Oct. '61) p. 60

Production Engineering, Materials, Structures

New aluminum alloy solves weld-treat problem

Reports on Tens 50 casting alloy, a weld filler for use with weldable and heat-treatable aluminum-magnesium-silicon alloy systems. Covers comparison tests of Tens 50 and other weld filler materials, applications of Tens 50, design of assemblies using this alloy, and welding and heat-treat methods.

by John G. Fisher, Rocketdyne

space/aeronautics 36/4 (Oct. '61) p. 87

Structures, Propulsion, Testing

Experimental stress analysis a must for solid-rocket cases

Analyzes the inadequacy of theoretical stress analysis for high-performance solid-rocket motor cases and discusses the requirements and problems of experimental programs to be used instead. Detailed data are given on a typical program of this kind.

by R. D. Evans & G. K. Schmitz, Solar Aircraft

space/aeronautics 36/4 (Oct. '61) p. 66

Electronics

Case studies in efficient heat transfer

Second of two articles on heat-transfer design for air- and spaceborne electronics. Uses cooling case histories for a TWT, transistors, vacuum tubes, and a high-voltage power supply to show how analytical methods explained in first article are applied.

by A. D. Kraus, Sperry Gyroscope

space/aeronautics 36/4 (Oct. '61) p. 114

THIS IS Hitco-C . . . A NEW CARBON MATERIAL

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abstracts

continued from page 7

Electronics

Power unit conversion

Nomograph for the conversion of any of the common power units—watts, milliwatts, microwatts, millimicrowatts, and kilowatts—to dbm.

space/aeronautics 36/4 (Oct. '61) **p. 121**

Electronics

Maser R&D

A detailed rundown of the maser, iraser, and laser development program of 25 industrial and university groups. Characteristics of nine typical operational solid-state maser amplifiers are tabulated.

space/aeronautics 36/4 (Oct. '61) **p. 139**

Electronics

Traveling-wave tubes extend microwave power

Reports on the modern low-noise traveling wave tube, calling it a match for the parametric amplifier. Such advances in TWT design as permanent-magnet focusing and electrostatic focusing are described.

by H. K. Jenny, Radio Corp. of America

space/aeronautics 36/4 (Oct. '61) **p. 122**

Accessory Systems

Spacecraft star tracker uses map-matching

Describes a star field tracker that will weigh less than 50 lb in its final form. Part of a feasibility study for the Apollo vehicle, the tracker is designed to provide reliable guidance and orientation for spacecraft.

space/aeronautics 36/4 (Oct. '61) **p. 184**

Electronics

Video correlator beats ECM and RFI (Design Digest)

Design details of a PRF-discrimination type of radar video processing system. Functional block diagrams and photographs are presented as well as comparative display-improvement data and before-and-after PPI and HRI scopes.

by Bernard Kovit, Associate Editor

space/aeronautics 36/4 (Oct. '61) **p. 127**

Support

Multi-point monitor warns of gas hazards

Describes a unit that detects and monitors the presence and amount of hazardous combustible gases at distances of up to 1500 ft.

space/aeronautics 36/4 (Oct. '61) **p. 226**

Electronics, Production Engineering

Welding for smaller, sturdier electronic packages

Discusses high-resistance spot-welding of "cordwood"-stacked components, one of the newest joining techniques for small and reliable electronic packages. This technique is said to require only very short component leads and to provide a high stiffness-weight ratio.

by J. R. Dow & E. J. Messner, Raytheon

space/aeronautics 36/4 (Oct. '61) **p. 131**

Electronics

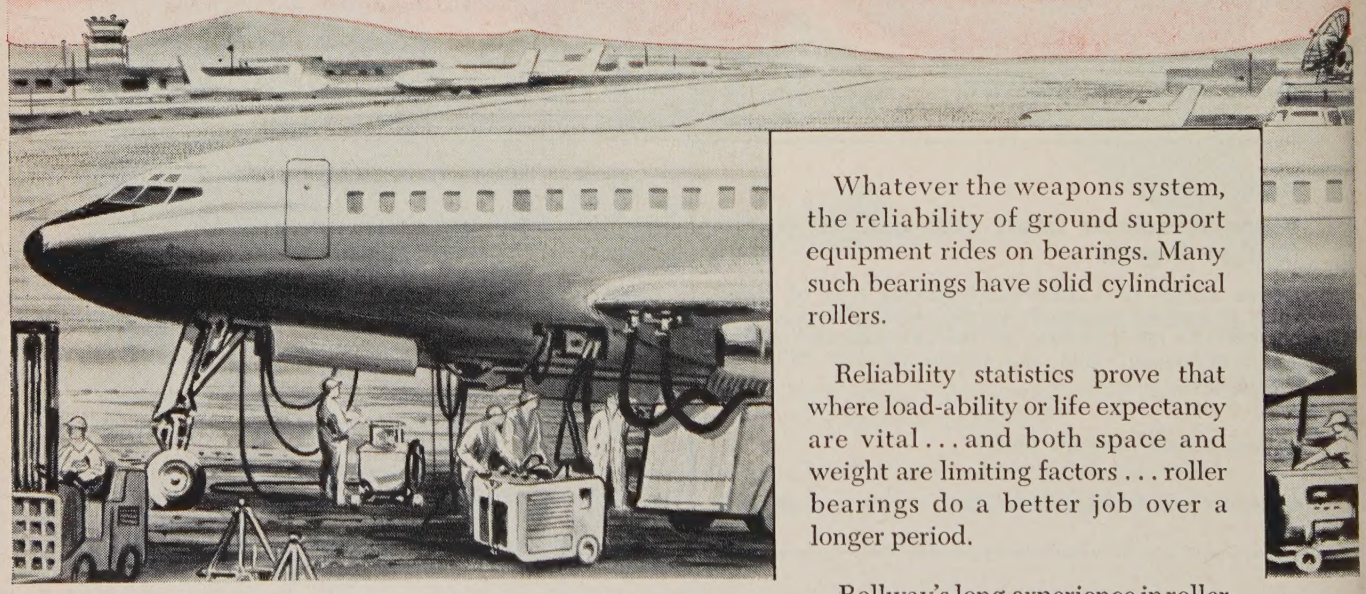
F-105D simulator sets complexity record

Reports on an electronic flight and tactics simulator for the Air Force's F105D fighter-bomber. System is said to be the most comprehensive flight simulator ever built.

space/aeronautics 36/4 (Oct. '61) **p. 234**

On the Ground as in the Air . . .

RELIABILITY rides on BEARINGS



Whatever the weapons system, the reliability of ground support equipment rides on bearings. Many such bearings have solid cylindrical rollers.

Reliability statistics prove that where load-ability or life expectancy are vital . . . and both space and weight are limiting factors . . . roller bearings do a better job over a longer period.

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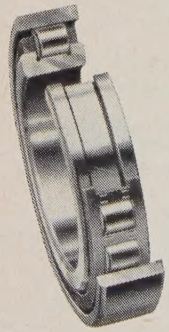

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Some Ideas

K+E

for your file of practical information on drafting and reproduction

KEUFFEL & ESSER CO.

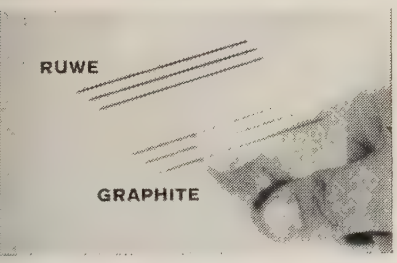
e stone tablet and chisel were pretty ely used writing and drawing instru- nts in their day.

they don't command much of a follow- any longer. Like so many tools of the t, they gave way to better methods of traying information. Some of these thods occurred by accident, some were eloped by experts to serve specialized ds. Three good examples of the latter described here.

A Couple of "Better" Pencils

nen polyester drafting film first came o use, it was found that standard phite pencils with clay binders, while e for paper, smudged too readily on film.

a new kind of pencil was needed—and veloped. It was called the Duralar. With h binder and color agent made entirely plastic, Duralar deposited a black, dense e on film, which could neither be udged nor washed away.



t since washability is not the touchstone every drafting operation, K&E went a p further. Result — the Ruwe pencil. ving all the "fine feel" and erasibility graphite, on both film and cloth, the we deposits a blacker, denser line than phite, with the smudge resistance the l graphite pencil could not provide.

re's why: the Ruwe pencil *is* graphite, t with a plastic binder instead of clay. lor coded in five degrees of hardness m 2S to 6S, Ruwe is available in wood ncils and leads. More good news is that we is now available in 2S and 3S hard- sses for fine-line automatic pencils as ll. The lead is just .036" in thickness — al for free-hand lettering.

interesting to note, that since the in- duction of Ruwe, other plastic-graphite ncils have been placed on the market. you're interested in testing the original 'll send free Ruwe pencils to you — just d the coupon.

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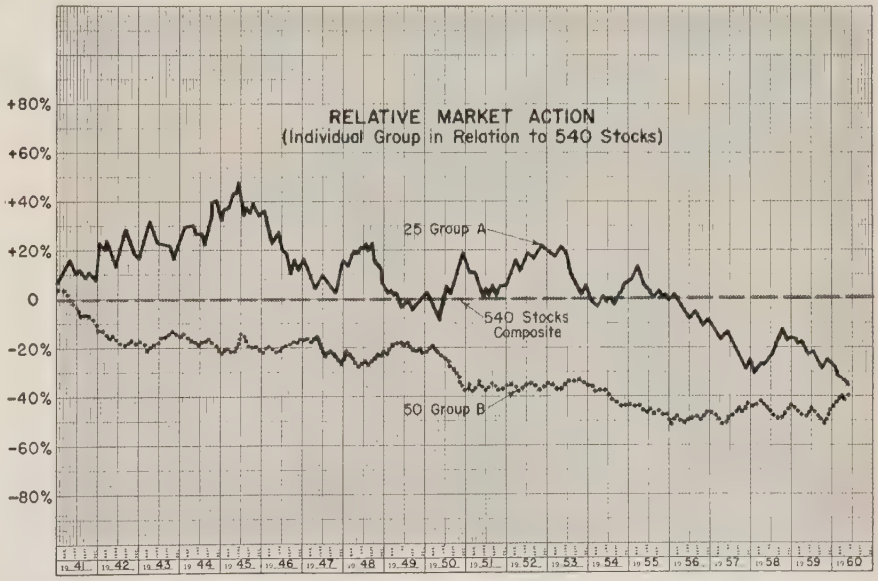
There is a lot more we could tell you about K&E graph sheets. We have prepared a selection guide for your use. If you'd like to have one, it's free, along with some sample sheets in the new *visual* package.



12,300 variables at a glance. Here's a typical stock market chart used to study relative market action. Center line is market behavior of 540 stocks over 20-year period. Two basic stock groups of 25 and 50 individual stocks, averaged, are plotted against market (figured at zero per cent). Resultant chart shows all-important slope of curve which — far more than gross increases — tells the story of the stocks' vitality. No list of statistics, no matter how exhaustive, could give the relative interactions shown here. This picture is possible only with a graph.

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PUTTING IDEAS TO WORK FOR NATIONAL DEFENSE

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AIRCRAFT DESIGN ENGINEERS

this is the "Hummingbird"

Engineering is now underway on the strange looking bird pictured here. We call it the "Hummingbird," and we are developing it for the U. S. Army.

It is to utilize the jet ejector augmentation principle for VTOL aerial vehicles to fly straight up, straight down, hover in mid-air, and convert to conventional forward flying at speeds in excess of 500 miles per hour. Just one example of what is going on here at our Engineering Center where dreams come true. Like to join us?

Openings in the fields of: Aircraft Design Engineering • Engineering Drawings Checking • Aircraft Structures • Flutter and Vibration • Sonic Fatigue • Aircraft Specifications Engineering • Reliability Engineering • Operations Research • Aircraft Research Engineering.

Write to: Hugh L. Gordon, Professional Employment Mgr., Lockheed-Georgia Co., 834 W. Peachtree St., Atlanta 8, Ga., Department Z-76.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

THE ENGINEERING CENTER

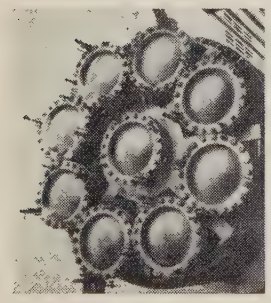
LOCKHEED-GEORGIA COMPANY

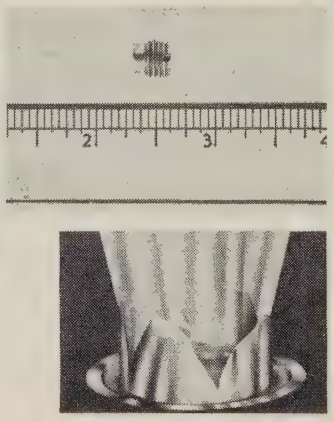
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

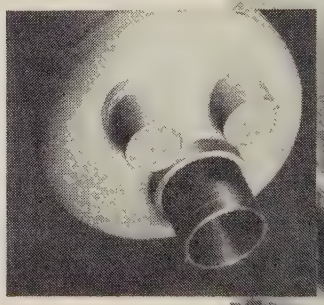
QUICK-OPENING VALVE . . . OR OVER-PRESSURE PROTECTION . . .

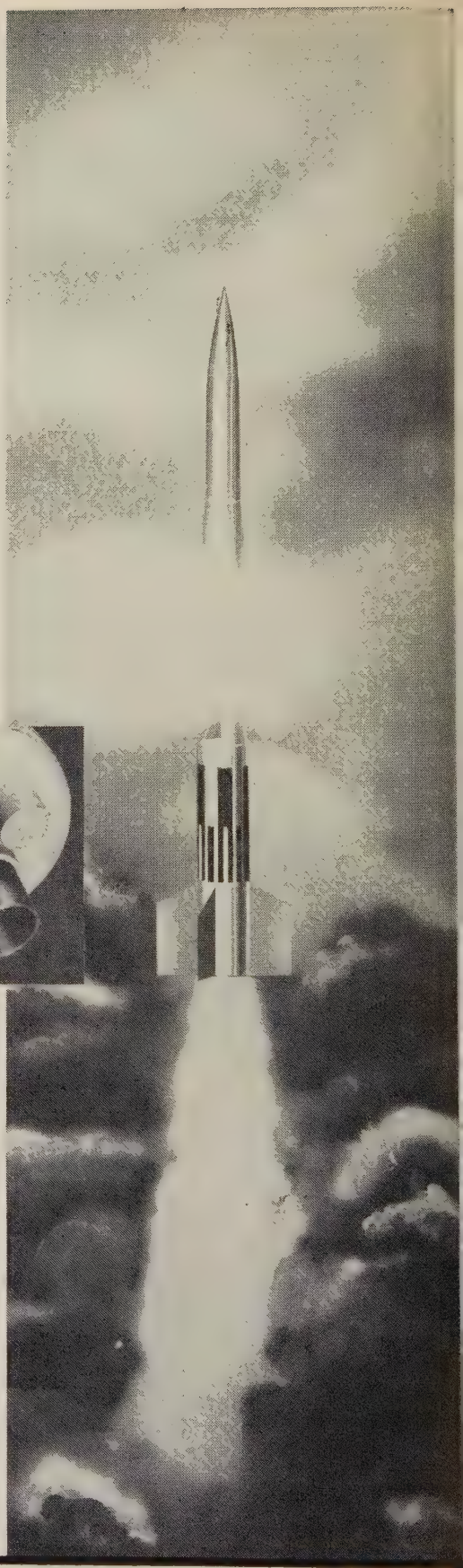
The BS&B Safety Head (rupture disc) will fit into most any pressure system that needs to be controlled or protected. For example, BS&B Safety Heads are now being used on Jato bottles, pilot ejection systems, fuel oxidation systems and missile hydraulic systems, serving as over-pressure protection or functioning as a quick opening valve.

A few years ago none of those uses were known. But as the industry has grown, and as new problems . . . both of a functional and control nature . . . developed, uses of rupture discs provided solutions to the problems of the aero/space industry.









The safety head is a light-weight metal disc enclosed in a holding mechanism . . . a flange or suitable placement device. This thin metal membrane will fracture or rupture at a pre-determined pressure to provide an instantaneous and complete opening. Various metals and plastic coatings render it virtually immune to corrosive chemical action.

We invite you to submit your problems on functional or over-pressure control to our Engineering Department. We will assist you in selecting a safety head of suitable design for your service requirement. Contact your local BS&B office, or write to: Dept. 2-HB10, 7500 East 12th Street, Kansas City 26, Missouri.

BS&B

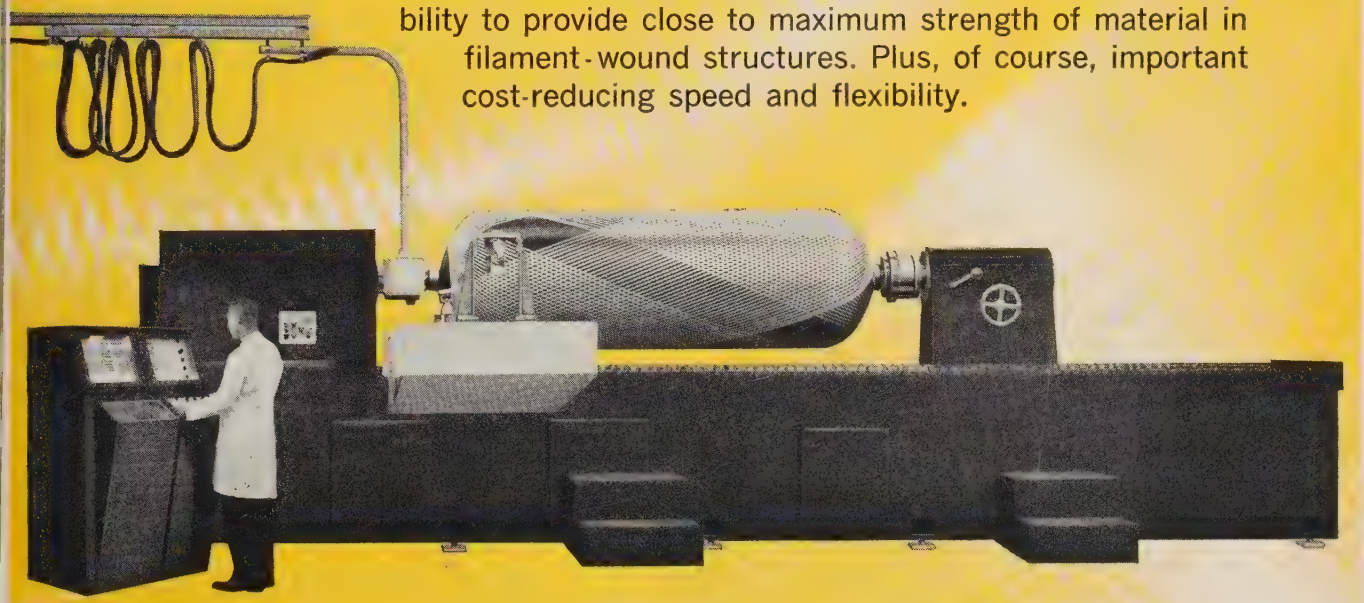
BLACK, SIVALLS & BRYSON

KANSAS CITY • OKLAHOMA CITY • TULSA • EDMONTON • THE HAGUE

No. 7 on Reader Service Card

ROHR WINDS UP LEADING THE FIELD

The industry's first tape-controlled, continuous-path filament winding machine is in full production now. Designed and built by Rohr, it wraps glass fibre filaments with amazing precision to form lightweight structures of great strength, such as the rocket motor case shown below. It is capable of winding parts up to 25 feet in length and 8 feet in diameter — and has the ability to wind an infinite variety of patterns, including a continuous filament pattern for multiple-nozzle motor cases. Actually, the wrapping of different pressure vessels is as simple as changing the tape. This advanced machine demonstrates Rohr's unique skill in designing and building highly specialized manufacturing equipment... plus knowledge gained from years of programming and production of three-dimensional parts by numerical control. The ability to produce precision-wound products on this new filament winding machine demonstrates the breadth of our research into plastics and adhesives and the depth of our experience in collapsible mandrel manufacture. Because it achieves such precise and uniform positioning of filaments, this Rohr machine now offers the industry the capability to provide close to maximum strength of material in filament-wound structures. Plus, of course, important cost-reducing speed and flexibility.



ROHR NUMERICALLY CONTROLLED FILAMENT WINDING MACHINE

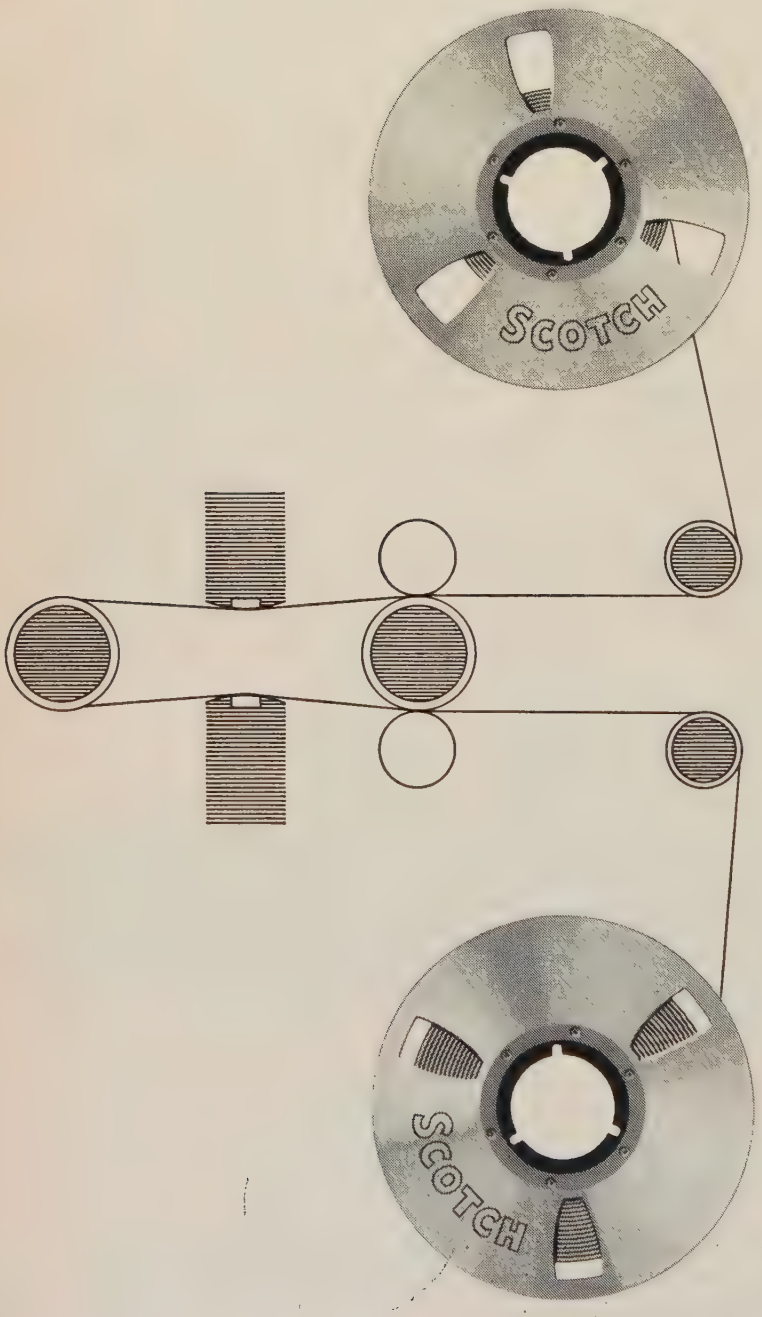
For information on this and other Rohr production techniques please write Mr. A. R. Campbell, Sales Manager, Dept. 60, Rohr Aircraft Corp., Chula Vista, Calif.

Main Plant and Headquarters: Chula Vista, California / Plant: Riverside, California / Assembly Plants: Winder, Georgia; Auburn, Washington

ROHR
AIRCRAFT CORPORATION

BEST SHORT WAVE LENGTH RESPONSE

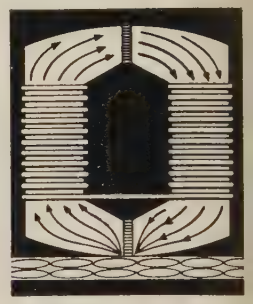
SCOTCH® BRAND High Resolution Tapes offer superior high frequency results



IN INSTRUMENTATION Tapes, a good *bit* may well depend on the character of the magnetic coating—and the uniformity with which it is applied. At short wave lengths, the head responds only to the flux nearest it—thus, the thinner the coating, the more it concentrates flux in that narrow region next to the gap where the head can use it best.

"SCOTCH" BRAND High Resolution Tapes 457, 458 and 459 testify to the great skill "SCOTCH" BRAND experts have in laying down a thin uniform coating that results in intimate head-to-tape contact, as shown in the diagram. This famous trio of tapes reproduces the critical short wave lengths, offers the superior response and resolution that lets you pack more information to the inch.

Much of their fine performance at high frequencies rests with the famed "SCOTCH" BRAND high potency oxides and their higher magnetic retentivity. At optimum bias settings, the coating is about 50% more sensitive to short wave lengths than ordinary coatings.



These tapes give you three great bases on which to build toward miniaturization. No. 458, with a 1.5 mil polyester base, offers standard recording time and maximum strength. No. 459, with a 1.0 mil polyester base, gives 50% extra recording time. No. 457, with a .65 mil base of tensilized polyester, delivers twice the standard recording time. One of the key factors in the consistent performance of the "SCOTCH" BRAND High Resolution Tapes is their uniformity—from reel to reel and within the reel. All three tapes offer a uniformity in magnetic coating and base that goes far to eliminate errors in performance.

In producing uniform tapes for all applications, nothing replaces the years of experience offered by the "SCOTCH" BRAND research and manufacturing team—the same team responsible for most tape advances. So check the entire "SCOTCH" BRAND line: Heavy Duty Tapes 497, 498 and 499 outwear ordinary tapes 15 times, even under adverse operating conditions. High Output Tape 428 offers top output at low frequencies. Sandwich Tapes 488 and 489 wear 30 times as long as ordinary tapes, cut head wear and oxide rub-off. And more reels of Standard Tapes 408 and 403 have been sold than any other kind.

Your nearby 3M Representative serves as a convenient source of information in all major cities. Contact him or write Magnetic Products Div., 3M Company, Dept. MBV-101, St Paul 6, Minn.

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"SCOTCH" is a registered trademark of 3M Company, St. Paul 6, Minnesota. Export: 99 Park Avenue, New York, N.Y. In Canada: London, Ontario.

SCOTCH BRAND MAGNETIC TAPE

FOR INSTRUMENTATION

MINNESOTA MINING AND MANUFACTURING COMPANY

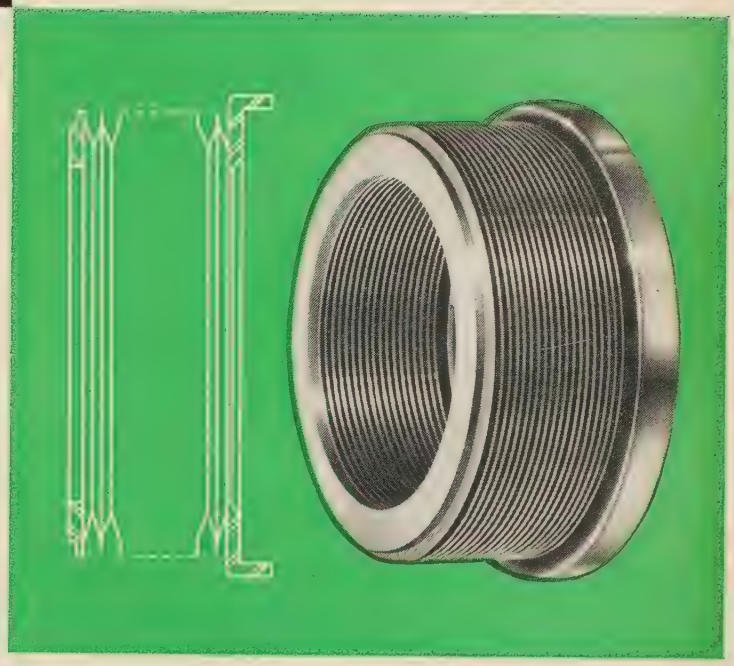
...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

No. 5 on Reader Service Card

C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

CHICAGO RAWHIDE MANUFACTURING COMPANY

1293 Elston Avenue • Chicago 22, Illinois

Offices in 55 principal cities

In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

Export Sales: Geon International Corp., Great Neck, New York

No. 10 on Reader Service Card

NORTH AMERICAN X-15

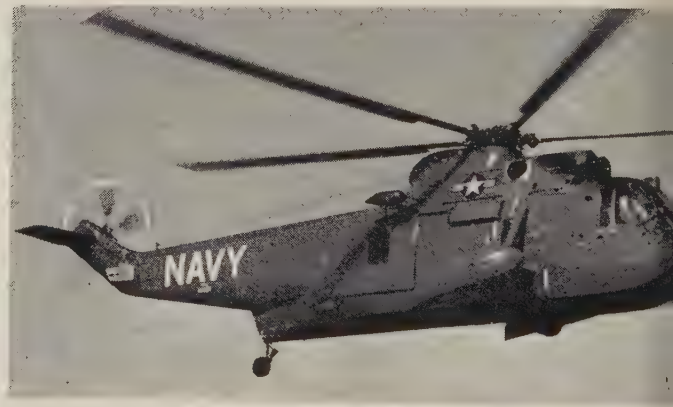
MARTIN TM-76B MACE

CONTROL

Why does the aerospace industry use more Cutler-Hammer switches and power relays than any other brand?

DOUGLAS A4D-2N

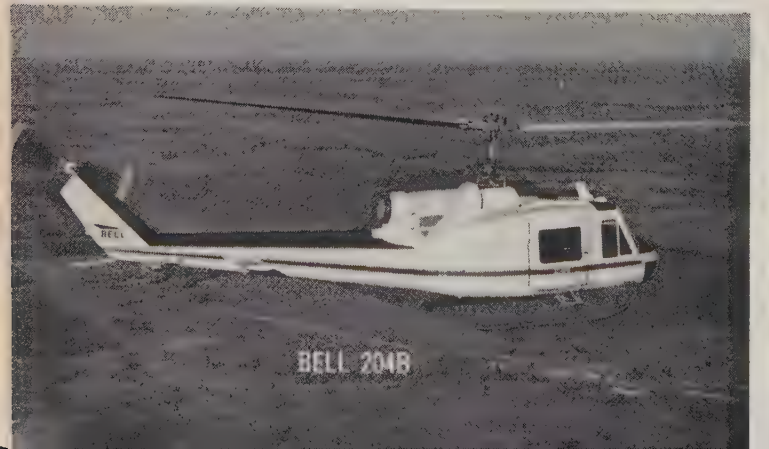
CESSNA 210



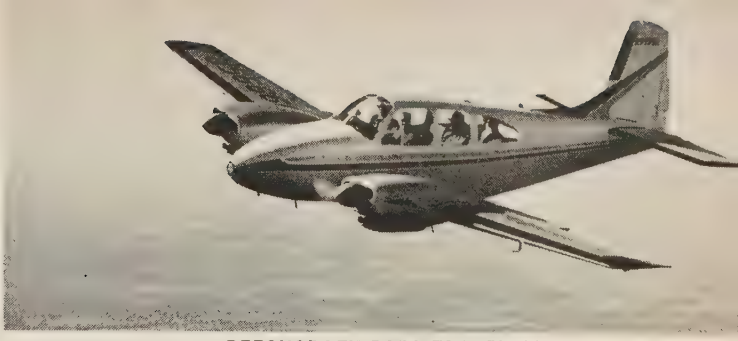
SIKORSKY HSS-2

REPUBLIC F-105-D

RYAN Q-2C FIREBEE

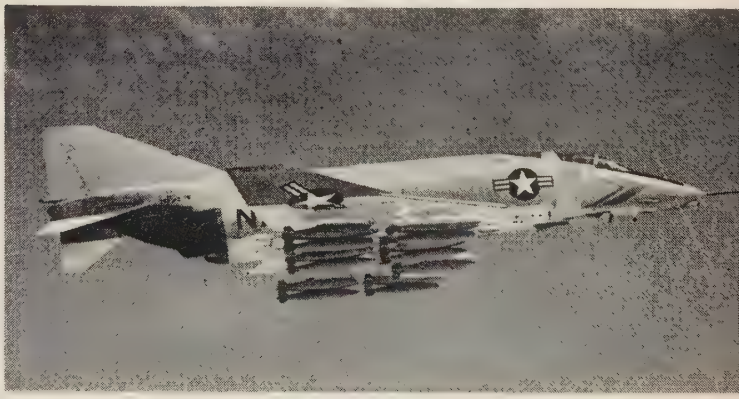


LOCKHEED F-104



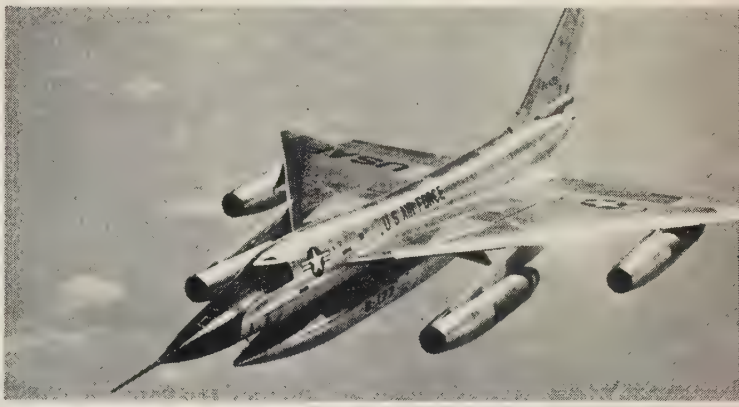
BEECHCRAFT B95A TRAVEL AIR

NORTHROP T-38



McDONNELL F4H-1

KAMAN H-43B HUSKIE



GENERAL DYNAMICS B-58

Reliability . . . breadth of line . . . experience have made

Cutler-Hammer first choice for switches and power relays

You'll find Cutler-Hammer switches and relays in all types of aircraft from private planes to missiles.

All the manufacturers represented in these photos—and many more—have made Cutler-Hammer a preferred source. Since 1920, when we designed and manufactured the first line of switches ever created specifically for aircraft use, Cutler-Hammer has been the standard of quality for the industry.

Our engineers are always ready to help you select the best possible switches, Class O and hermetically sealed power relays and circuit breakers from our extensive line. Or, they'll work with you in design and manufacture to help you solve your particular problem. Better yet, get in touch with your Cutler-Hammer sales office *before* a special problem comes up. For more information, write for Pub. EE 140-U287—88 pages of detailed information.

WHAT'S NEW? ASK...

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. • Associates: Cutler-Hammer Canada, Ltd.; Cutler-Hammer Mexicana, S. A.

CONTROL

No. 11 on Reader Service Card

Opportunities for:

Aerospace Vehicles Engineers

The Aerospace Vehicles Laboratory of the Space Systems Division has openings for nearly one hundred engineers who have experience in stress, structures, propulsion, mechanisms, control systems, equipment installation or heat transfer which can be applied to advanced aerospace weapons systems or vehicles. The Aerospace Laboratory is concerned, as a result of SURVEYOR and other contracts, with lunar and space exploration, air to air missiles and ICBM defense systems. The openings are for both junior and senior mechanical engineers, electronic engineers, physicists and aeronautical engineers. Some of the openings are described below:

Structures

Senior Dynamicist. Must be capable of performing advanced analysis in structural mechanics. Will be required to calculate response of complex elastic systems to various dynamic inputs including random excitation. Must be capable of original work in developing advanced analytical techniques.

Loads Analyst. To establish structural design criteria for advanced missiles and spacecraft. Should be capable of determining external airload and inertial force distributions.

Reliability Analyst. To perform statistical analysis of structural loads and strength properties for the purpose of establishing structural reliability criteria on a probability basis.

Stress Analyst. To perform advanced stress analysis of complex and redundant missile and spacecraft structures. Will be required to solve special problems in elasticity, plasticity, short time creep and structural stability.

Design. Experience is required in preliminary and final structural engineering and design, including preliminary stress analysis. A knowledge of the effects of extreme temperature environment and hand vacuum, plus a background in materials is desired.

Heat Transfer

Space Vehicle Heat Transfer. Basic knowledge of radiation conduction and convection heat transfer with application to thermal control of space vehicles is required. Knowledge of spectrally-selective radiation coating, super-insulations and thermal vacuum testing is of particular value.

Aerothermodynamicist. Experience in hypersonic real gas dynamics, heat transfer, abalation; re-entry vehicle design, detection; shock layer, wake and rocket exhaust ionization; and anti-missile system requirements will be most useful.

Equipment Installation

Packaging and Installation Engineer. To perform optimum packaging and installation design for missile and/or spacecraft units, considering amount and geometric shape of space available as well as weight and center of gravity distribution requirements. Must be capable of analyzing structural adequacy of unit under extreme environmental conditions.

Controls

Optical Devices. Design, development, procurement and test operations are involved. Considerable experience in the field of optical devices for space applications such as star, horizon, sun and moon trackers.

System Test. To plan and supervise the operations of a flight control system laboratory. Air bearing tables and a wide variety of optical mechanical and electrical equipment are involved.

Control System Analysis. Requires engineers at various levels of experience including senior men capable of taking over-all project responsibility in the synthesis and analysis of control systems.

Circuit Design and Development. Experience in design and development of transistorized control system circuits, including various types of electronic switching and modulation techniques is required.

If you are a graduate mechanical engineer, electronic engineer, physicist or aeronautical engineer, with experience applicable to the above openings, please airmail your resume to: **Dr. F. P. Adler,** Manager, Space Systems Division, Hughes Aircraft Company, 11940 W. Jefferson Blvd., Culver City 20, California.

WE PROMISE YOU A REPLY WITHIN ONE WEEK

An equal opportunity employer.

Creating a new world with Electronics

HUGHES

HUGHES AIRCRAFT COMPANY

SPACE SYSTEMS DIVISION

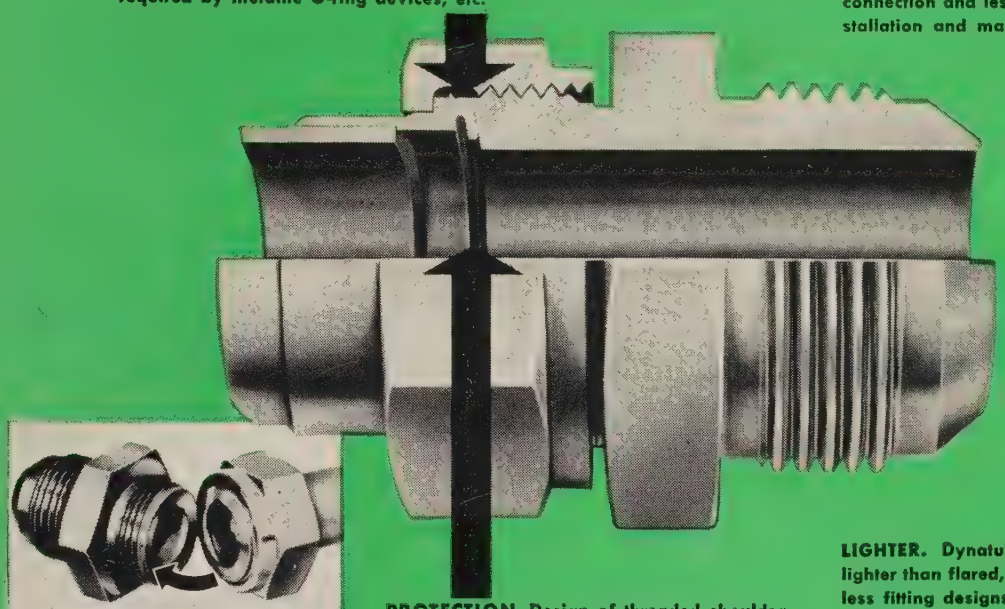
Leakproof Coupling
for High-Performance Systems

DYNATUBE*

A NEW DYNAMICALLY SEALED TUBE CONNECTION BY RESISTOFLEX

DYNAMIC SEALING. Dynatube design incorporates a dynamic seal whose efficiency increases with elevated pressures—without need for extreme machine finish such as that required by metallic O-ring devices, etc.

SPACE SAVER. Smaller envelope of Dynatube means easier wrench access, less distance across hex corners, less protrusion of total connection and less clearance needed for installation and maintenance in critical uses.



METAL-TO-METAL contact forms full seal at torque range between 26 foot-pounds and 200 foot-pounds, compared with 7 foot-pound range (110 to 117 fp) for flared fittings in the —16 size.

PROTECTION. Design of threaded shoulder permits the nut to act as a protective cover for the tube end, minimizing possibility of damage to seal. Dynatube is considerably stronger than standard AN or MS fittings.

LIGHTER. Dynatube fittings are markedly lighter than flared, modified flared and flareless fitting designs . . . offering up to 74% weight savings over flared fittings, combined with zero leakage because of pre-determined stress level at seal.

*Dynatube is a Resistoflex trademark.
U.S. and Foreign patents applied for.

Dynatube, another *first* by Resistoflex, is an all-new concept in metal rigid tube connections . . . providing a superior seal for high performance hydraulic, pneumatic, fuel and oxidizer systems.

Dynatube provides maximum performance because

- The seal is controlled by precision dimensions built into the fitting
- The fitting design is based on pre-determined stress level at the sealing point
- Torque range is extremely wide

Dependence on surface finishes of sealing seats, concentricity of AN and MS screw machine parts and torque application is completely eliminated with Dynatube.

Severe temperature cycling does not affect the Dynatube seal, which maintains its reliability up to 700° F. and higher, depending on application. Not sensitive to torque degradation, Dynatube has a smaller envelope and is lighter and stronger than corresponding AN or MS fittings. Meets or exceeds all performance requirements of proposed MIL-F-18280B.

Here is the answer to your tube sealing problems. Ask your Resistoflex field engineer about Dynatube, or write to Resistoflex, Roseland, N. J. for Bulletin DY-1.

RESISTOFLEX

RELIABILITY

COMPLETE SYSTEMS FOR CORROSIVE SERVICE

No. 12 on Reader Service Card

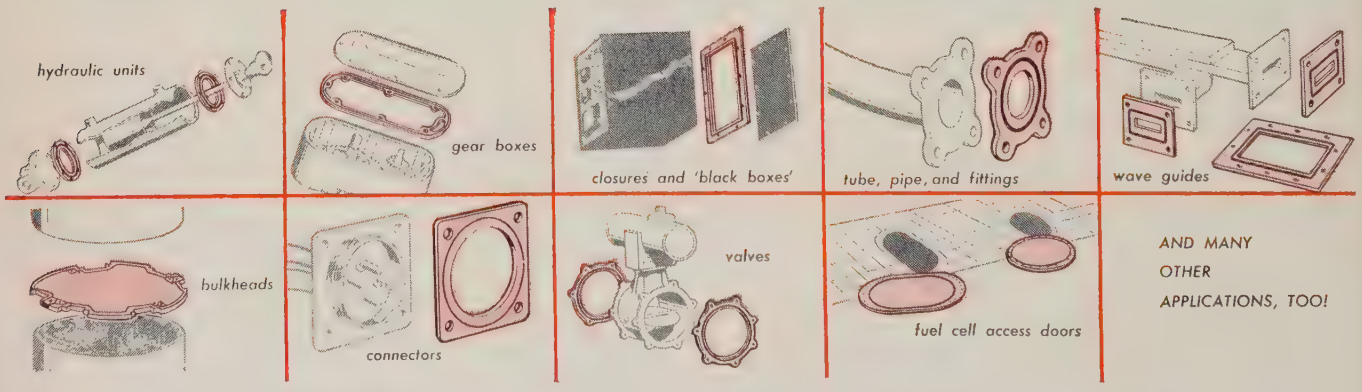
LEAKS *CAN* BE STOPPED!

Controlled Confinement

Safe, sure sealing is vital in today's high performance machines, aircraft missiles, ground support equipment and processing equipment and *there* is a better way to seal them . . . GASK-O-SEALS.

The Gask-O-Seals shown here are static seals that can actually provide sealing that will exceed hermetic top specifications. Yet, they are mechanical, can be removed, and reused. *Controlled confinement* of the rubber makes them superior to other seals.

The "typical" applications shown are just a few of the ways Gask-O-Seals are being used. Practical, *truly* economical, no-leakage sealing. If you want to *seal* for *sure*, find out about Gask-O-Seals. Just drop us a line or use the reader service card.



Parker SEAL COMPANY

CULVER CITY, CALIFORNIA and CLEVELAND, OHIO

A DIVISION OF PARKER-HANNIFIN CORPORATION

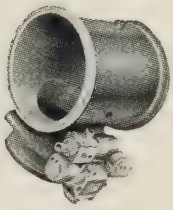
No. 13 on Reader Service Card

3M COMPANY CHEMICALS

THE RAW MATERIALS OF PROGRESS

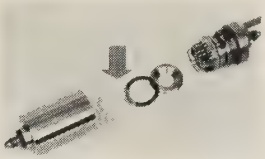
KEL-F® 81 Plastic foils heat, cold, corrosion, shock—how can it serve you?

BRAND



Seals of KEL-F Plastic remain flexible, even at –320°F.

LOX and JP fuels, other corrosives can't faze it!



Pressure diaphragms stay accurate from 0 to 160°F.

On the launching pad, aloft in outer space . . . KEL-F 81 Brand Plastic helps tame extreme high and low temperatures, defeat violent acceleration and shock, make corrosive chemicals behave!

For liners and seals in flexible ball joints, for example, KEL-F Plastic is easily cut to shape, resists the highly corrosive attacks of LOX and JP 3, 4 and 5 fuels! In valves handling LOX fuels, seals of KEL-F Plastic remain flexible, withstand 1,000 opening and closing cycles, even at –320°F. And in pressure differential pick-ups, diaphragms of this plastic resist such corrosive media as red and white fuming nitric acids and hydrazine—operate efficiently from 0 to 160°F., with less than 2% sensitivity change in 100-degree change of temperature.

In missile-borne electronic gear, KEL-F Plastic is used for bobbins in miniature relays because this plastic's excellent electrical properties minimize surface "creep" of electric current. Typical electronic applications, even at high temperatures, also include wire coating, printed circuits, radome covers, switches, sockets, other parts.

Check the properties detailed at right, then call the 3M Chemical Representative to help put the many talents of KEL-F 81 Plastic to work solving your problems.

"KEL-F" is a reg. TM of 3M Co.

PROPERTIES PROFILE

KEL-F® 81 PLASTIC

BRAND

RESISTS CHEMICALS! KEL-F 81 Plastic is unaffected by corrosive chemicals—resists most missile fuels, organic solvents, strong caustics, oxidants, concentrated acids, even fuming nitric.

RESISTS SHOCK AND WEAR! Even thin wire coating of KEL-F 81 resists extreme vibration, acceleration, shock, cut-through and cold flow, even at –69.5°F—retains flexibility at even lower temperatures. Tough, smooth surface is not easily abraded mechanically or by abrasives in slurries or in the atmosphere. Specific physical properties in crystalline state:

Tensile strength.....(77°F.) 4900 psi
Impact strength..3.1 ft. lb./in. of notch
Compressive strength
(0.2% offset).....5440 psi
Modulus of
elasticity.....(77°F.) 186 x 10^3 psi
Shear strength.....(77°F.) 5440 psi

HIGH DIELECTRIC STRENGTH! Arc resistance is greater than 360 seconds. Specific dielectric strength characteristic in amorphous state:
Short time 2″.....1010 v/mil

800-DEGREE RANGE! Extreme thermal stability permits use from –400 to +400°F. Zero moisture absorption, non-wettability assure stability in high humidities.

MOLDABLE AND MACHINABLE! KEL-F 81 Plastic may be molded by injection, extrusion, compression and transfer methods—may be drilled, punched, machined, cut, engraved, sanded and polished to produce parts with high degree of precision.

WANT TO KNOW MORE? Call the nearby 3M Chemical Representative for complete information, technical assistance on KEL-F 81 products or on more than 300 other specialty chemicals and materials. Or write 3M Chemical Division, Dept. KAO-101, St. Paul 6, Minn.

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

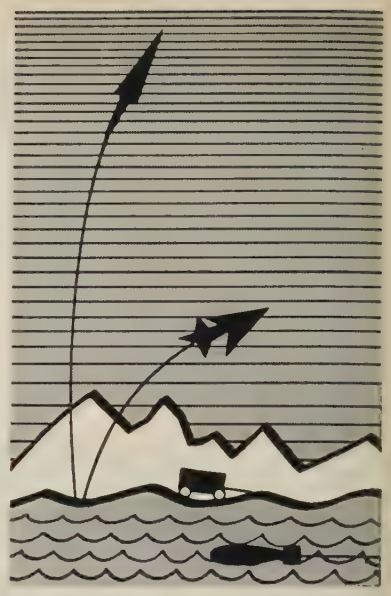
...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

No. 14 on Reader Service Card

message to engineers on all types of space* projects using valves

*INNER, OUTER, IN-BETWEEN . . . EVEN UNDER!



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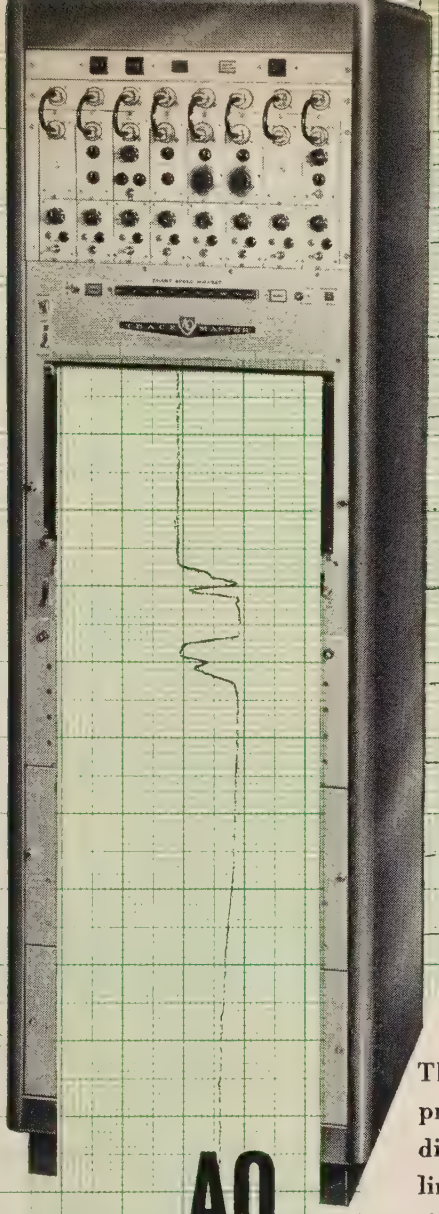

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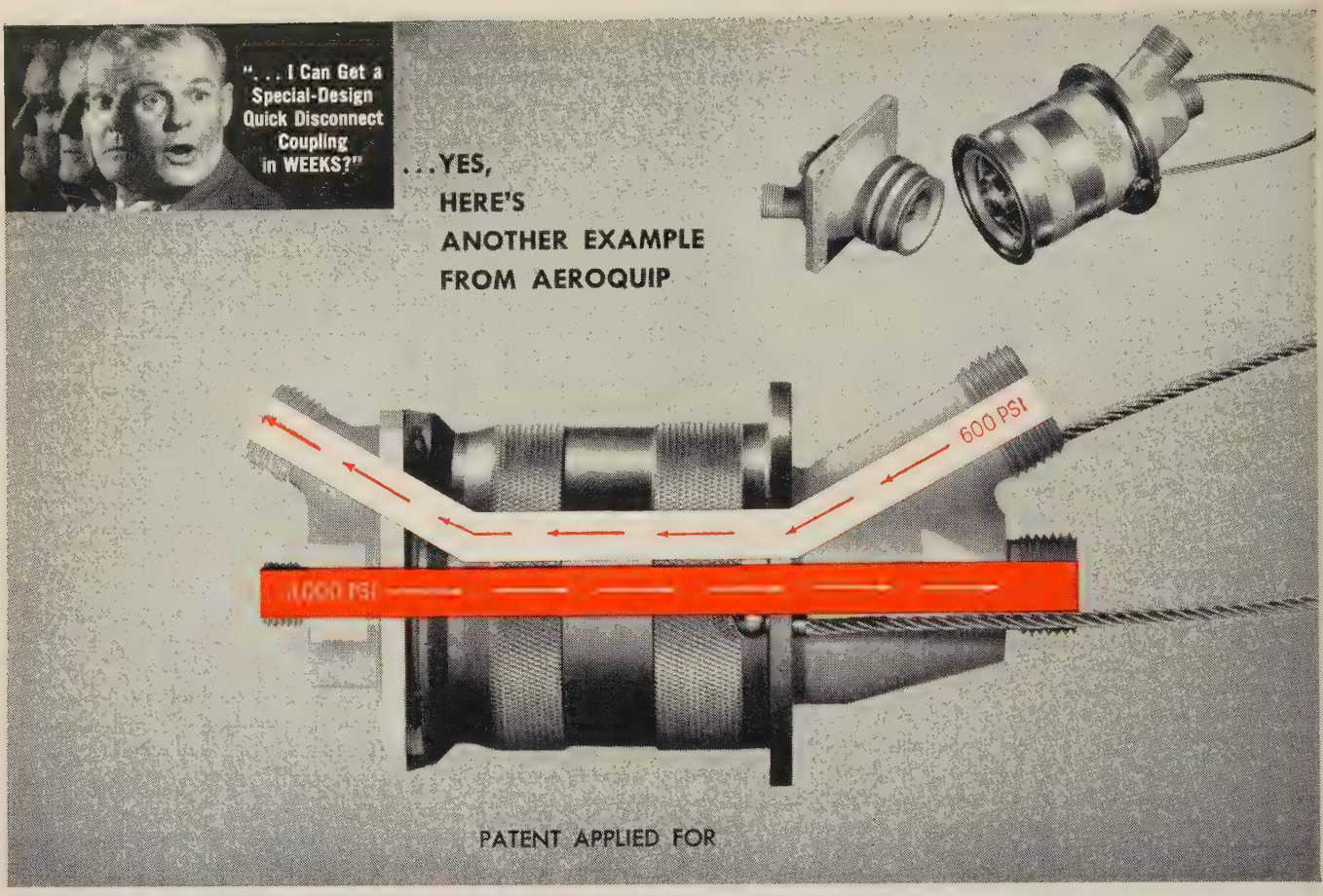
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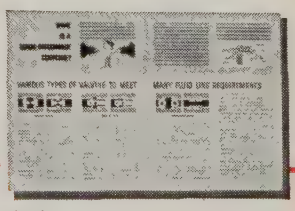

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No. 16 on Reader Service Card

Engineers deserve more recognition

WE HAVE BEEN spending a good deal of time recently studying the returns to the surveys on which our new Readers' Round Tables are based. Especially what our engineering readers had to say about why they change jobs made fascinating reading (see *p. 274*).

Although our sample was small, some basic conclusions from our last survey can be established beyond statistical doubt:

- At any given time, a suspiciously large number of engineers in the aerospace industry appears to be thinking of quitting. Out of 134 engineers who filled in our last questionnaire, 58 say they are at least wondering whether they should change jobs—*though over half of them have no beef about their salary.*
- Many engineers who are dissatisfied with their jobs complain strongly that their companies are letting them down by not getting contracts involving challenging engineering work or by not providing their engineering staff with clear overall technical goals to shoot at.
- Almost as many complaints are voiced about the lack of authority to go with the engineer's responsibilities, about lacking opportunities for technical creativity, and about harassment by petty rules and regulations.

What this adds up to, we think, is that most engineers in the aerospace industry feel that they deserve more recognition. We think they are quite right.

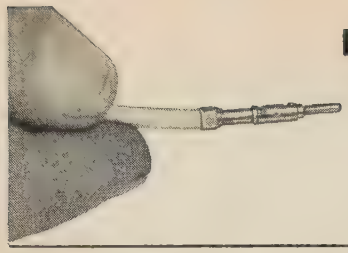
How many of the men who employ engineers, we sometimes wonder, ever stop to consider what an odd breed today's engineers are? To coin a stuffy phrase that should delight the sociologists, engineers are the only professionals subject to mass employment. Most other professionals work either for themselves or in small and fairly independent groups. You don't find bullpens full of doctors or lawyers.

Since we can't change the basic character of industries like aerospace, there's no way of getting rid of the engineering bullpen in one form or another. Being an engineer unfortunately means that you risk getting lost in a crowd.

Still, recognition is possible even for "mass-employed" groups. It involves several things that are quite simple, and it's rather puzzling why management so often overlooks these when it comes to engineers.

Engineers want to know what is going on. They are, after all, professionally involved in their work. We believe it would do a lot for their morale if their companies kept them well informed of the plans and prospects for future work. Even more would be achieved if companies went to the trouble of devoting some special attention to the little annoyances that make life miserable for their engineers. Some of these annoyances probably are inevitable—but then at least an intelligent explanation can be given for them.

In our age of public relations, this isn't much to expect. Nor is it all the recognition that engineers deserve but aren't getting. But it is the best place for a start in the right direction.



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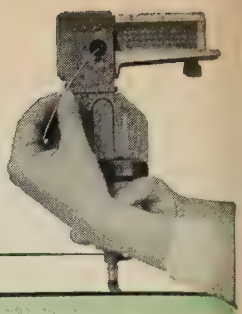
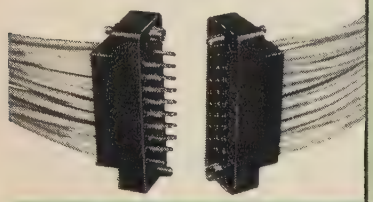
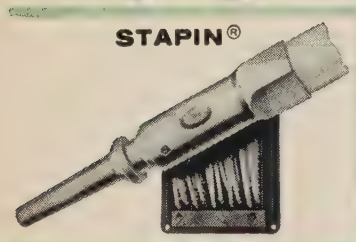
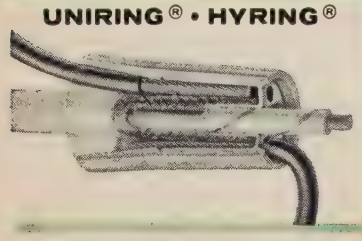
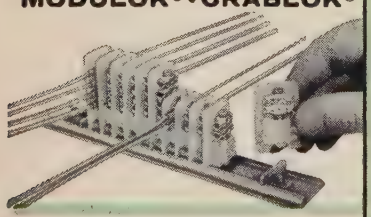
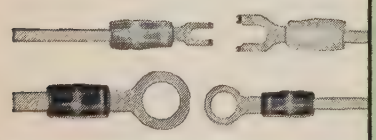
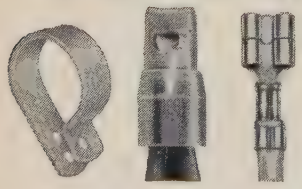


Photographs of products are not to scale.	DEFINITIONS	TYPES	FEATURES
HYFEN® 	Plug and receptacle connectors with crimp-type, snap-locked contacts.	Miniature rectangular, rack and panel, general purpose, modular, plug-in relay base, printed circuit—pin and edge type, coaxial—miniature and standard, BANTAM, round.	Tool-installed crimped contacts are individually or gang connected and disconnected. Extremely versatile and reliable. Quality materials used for inserts and contacts which are normally gold plated. Modular concepts.
STAPIN® 	Solid shank, solid barrel taper pins for wire terminations in variety of receptacles.	Sealed, terminal blocks, modular frames and inserts, coaxial, console mount, bussed, stacking strips.	Rugged solid construction provides protection against repeated and rough handling. Tool-installed STAPIN quality-controlled by tooling.
UNIRING® • HYRING® 	Compression sheath connector for terminating and grounding shielded or coaxial cable.	one-piece UNIRING, two-piece HYRING, both in complete size ranges.	Tool-installed, eliminates possible heat damage to conductors, dielectric, and insulation. Both available preinsulated or uninsulated. Conforms to MS25311 and MS25312 (AER).
MODULOK® • CRABLOK® 	Quick-disconnect or permanently-connected terminal blocks.	2- or 4-tier MODULOK. 5- or 15-bay CRABLOK.	Extremely versatile modular design. Reliable electrical contact in both quick-disconnect or permanent connection position. Tool-installed crimp-type contact tips.
INSULUG® • HYLUG® 	Compression terminals, splices.	Round, fork, right angle, flag, high temperature insulated and uninsulated.	Hand, semi-automatic, and fully automatic tooling—with removable dies—provide up to 1000 quality-controlled connections per hour.
WIRING SPECIALTIES 	Cable hangers, pigtail splices, strip terminals.	NYLOCLIP® BURCAP® FINGRIP®	Compression connections, tool controlled. NYLOCLIP strong, light, environmentally resistant.

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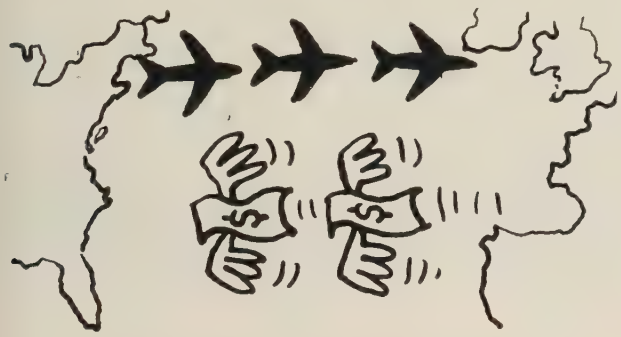
No. 17 on Reader Service Card

U.S. firms to enter NATO competitions

U. S. aerospace companies may have found a new customer for their products, especially V-STOLs. NATO has asked American firms for bids on two new aircraft, and T. C. Muse, director of aeronautics in the Office of the Director of Defense Research and Engineering, has briefed more than 200 industry representatives on the requirements.

The first craft is a medium-range transport, for which proposals must be



submitted by Nov. 16. The other is a strike and reconnaissance fighter with a proposal deadline of Dec. 31.

Actually, NATO has procured U.S. aircraft and engines before. The Lockheed F-104 and North American F-86, and the GE J79 and J47 engines to power them, were procured "off the shelf." But the new competitions mark the first time American manufacturers have been invited to bid on new aircraft at the design stage.

In the past, this country has sought to build up the productive capabilities of European plane builders, simultaneously pumping dollars into the Western European economy. As a result, competitions for new NATO aircraft were effectively limited to British, French, Italian, Dutch, and Belgian aircraft producers. (West Germany was precluded from producing military aircraft under post World War II agreements.)

Now the situation has changed. Western Europe is back on its feet while the U.S. is worried about an unfavorable balance of trade and the drain on the gold supply at Fort Knox.

To help rectify the situation, Treasury Secretary C. Douglas Dillon quietly passed the word to the Pentagon and to NATO headquarters in Paris that he would like future NATO competitions opened to U.S. firms. The European manufacturers don't like the revision, but there is little they can do about it—the U.S. still supplies the bulk of NATO procurement money.

Aside from possible creation of a new market for American firms, the two competitions have a secondary advantage—they pave the way for a second source of support for research on V-STOLs.

If U.S. companies should win one or both NATO development contracts, the research will still be paid for by the U.S., but it will be out of Mutual Defense Assistance Pact funds rather than the Pentagon's R&D money.

Impetus to Mach-3 programs

The Moscow Air Show threw a bigger scare into the Pentagon than anyone is willing to admit publicly. Until now,

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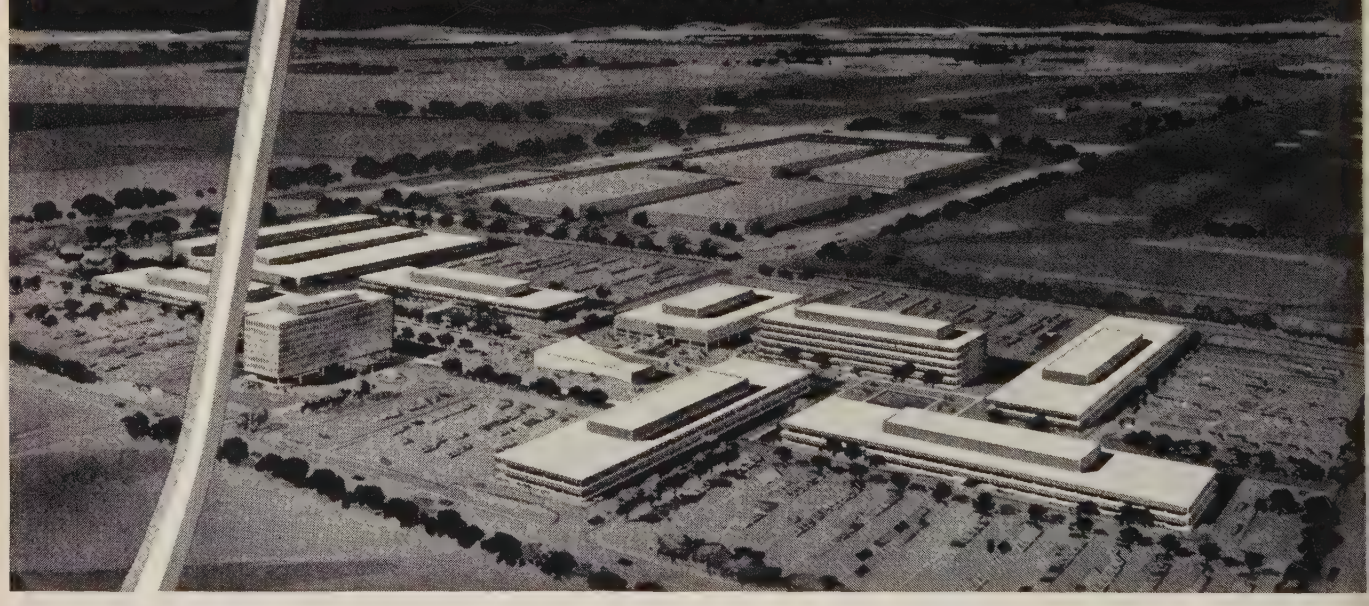
This November, eleven months after groundbreaking, the free world's most experienced industrial space scientists and engineers will be at work in STL Space Technology Center, on a 110-acre site at One Space Park, Redondo Beach, California. The spectacular compression of time, in conceiving, planning and constructing America's newest and largest facility for advancement of space science and technology, is testimony to the effectiveness of applying the systems approach to construction. It is made possible by pooling the experience, knowledge, management and technical skills of the owner, Space Technology Laboratories, Inc., the architect, Albert C. Martin and Associates, and the engineer-constructor, Twaits-Wittenberg Co.



STL Space Technology Center is a planned environment for Space Technology Leadership, and its construction is a milestone marking the continuing growth and diversification of Space Technology Laboratories, Inc. The outstanding facility of its kind, it is expressly designed for the outstanding men of their kind: engineers and scientists whose high order of achievement is demonstrated by their contributions to the nation's ballistic missile and space programs. The increasing requirements of STL's responsibilities in such programs as OGO, ADVENT, ATLAS, TITAN, and MINUTEMAN, create immediate opportunities in Southern California and at Cape Canaveral for engineers and scientists of talent and vision. All qualified applicants, regardless of race, creed, color or national origin, are invited to communicate with Dr. R. C. Potter, Manager of Professional Placement and Development.

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the official reactions boiled down to statements like: "We knew about most of the aircraft they showed us. There were a few surprises, but our bombers and fighters still give us enough deterrent capability."

However the Air Force, which is preparing to award a development contract for a tactical fighter to replace the F-105, has postponed the final design specs. Aside from differences with the Navy on weight and altitude characteristics of the upcoming TFX (tactical fighter, experimental), the USAF still hasn't decided how much performance to build into the new plane.

Before the Moscow Air Show, the AF was considering a Mach-2 STOL. Since the Russian demonstrations, USAF operational requirements officals have been quietly asking airframe and engine companies for estimates of costs and time required to make the TFX a Mach-3 airplane.

If the companies submit time and price schedules that DOD Comptroller Charles Hitch considers reasonable, the AF will contract for a Mach-3 TFX. If engine unavailability or technical problems would cause excessive delay, the TFX will remain in its original form.

Decline in manned-aircraft R&D

Concern is mounting in the Pentagon and the Federal Aviation Agency about the decline in research on aerodynamics, structures, materials, and other problem areas of ordinary manned aircraft.

Although the Navy, the Air Force, and NASA are all intensively studying space headaches—from the Van Allen radiation belt through human reaction to weightlessness for extended periods—relatively little is being done anywhere for less than hypersonic operations.

Air Force Chief of Staff Gen. Curtis E. LeMay repeated the prevalent military belief when he declared: "I can say confidently that the missile is never going to replace the man." If LeMay is correct, then the amount of aeronautical R&D is unsatisfactory.

Vice Adm. John T. Hayward, Deputy Chief of Naval Operations (Development) points out: "We must extend our investigations to explore many new ideas in engines and airframe construction. To produce the weapons systems needed for today and tomorrow's military forces, we must reenergize and support broad aeronautical research in NASA, in the services and in industry."

Actual breakdown of how much is being spent on basic aeronautical research is difficult to obtain, primarily because the studies are conducted by so many groups.

In the days when NASA was the National Advisory Committee for Aeronautics, before Sputnik I, it was spending about $50 million a year in-house at the Langley, Lewis and Moffett Aeronautical Laboratories and basic research on manned planes.

The Langley, Lewis and Moffett Research Centers are now spending less than half that sum on manned-flight research, though NASA's overall R&D budget has multiplied several times since '57. The emphasis is on space projects, in line with White House directives.

The Federal Aviation Agency's research installation at Atlantic City has taken over many studies which once would have been assigned to NASA. The FAA Bureau of Research and Development, which operates the Atlantic City facility, makes no attempt to show that the New Jersey center can or should carry on manned aircraft R&D. "We would like to see someone - anyone - get back into the airplane research business," FAA officials assert.

OUTCOME OF TESTS ON PROJECTS PLUTO AND ROVER TO DETERMINE ATOM-ENGINE SPENDING IN '63

The nuclear-powered airplane is almost dead, but the Air Force, NASA and the Atomic Energy Commission are ready to step up expenditures for atomic-powered ramjet and rocket engines in fiscal '63.

Joint Congressional Atomic Energy Subcommittee on Research and Development has been told by officials of the three agencies that both Project Pluto and Project Rover, the nuclear ramjet and rocket programs, are on the verge of new tests. If these tests warrant increased R&D, the big-money additions will show up in the budget President Kennedy submits next January.

Rep. Melvin Price (D., Ill.), chairman of the atomic R&D subcommittee, has expressed unhappiness about the current Rover program. Latest AEC-NASA testing schedule for Rover calls for test of the Kiwi-B gasous-hydrogen reactor in October and of the liquid-hydrogen reactor early next year. This would pave the way for flight tests in 1966 or 1967.

Pluto testing estimated at $500 million

But AEC Chairman Glenn T. Seaborg indicates successes in the program could permit acceleration of flight testing "possibly in 1965." Contractor for the Rover Vehicle will probably be selected early in 1963 and the entire program will be reviewed after the spring tests to determine whether nuclear upper stages can be used in early efforts to explore the moon.

The Pluto nuclear ramjet's future is now being decided by an ad hoc group which was to deliver its recommendations to Dr. Harold Brown, DOD's director of research and engineering, at the end of September.

With about $100 million already invested in Pluto by DOD and the USAF, total cost of the program through the flight test stage is estimated at $500 million, with the USAF providing 75-80 per cent of the cash.

USAF, which sees Pluto as the forerunner of a supersonic low altitude missile (Slam), has conducted its own evaluation and concluded the next step should be more ground tests of a complete nuclear ramjet engine, with flight testing to follow.

To carry on this program, the USAF would have needed $23.4 million during the current fiscal year. But the money was not sought in either the Kennedy or Eisenhower budgets for fiscal '62 because first tests of the Tory-II-C reactor prototype are not programed until next year.

The USAF told DOD and the ad hoc group the follow-on effort should be undertaken at a cost "a good deal more than the $23.4 million." USAF's proposal involves developing an engine feasible for ramjets and starting manufacture of non-nuclear components. The AF also wants to start developing Slam subsystems.

USAF currently lists Pluto as a Category-3 R&D item—a project it would be nice to have if the money were available. The new financing proposal would push Pluto up to Category 2 again.

AID PROGRAMS TO BOOST U. S. BUSINESS BY BILLION

U.S. Military aid programs, involving overseas output of three weapon systems—F-104, Hawk and Sidewinder—will result in about $1 billion in business for American aerospace firms.

The Pentagon says the Starfighter program will be the biggest dollar-earner for U.S. companies. Belgium, Holland, Italy and West Germany have earmarked $1.5 billion (including $145 million from the U.S.) for F-104G procurement. Between $800 and $900 million, including all of the U.S.-provided money, will go for U.S.-built components and technical service.

Another version, the F-104J, is being built in Japan. Total expenditure on the F-104J will come to $194 million, of which $161 million will go to U.S. manufacturers.

U. S. firms can expect $125 million

The Hawk anti-aircraft missile program in Europe amounts to $500 million, with Belgium, France, Italy and West Germany taking part. U.S. firms can expect $125 million of the Hawk total.

Sidewinder infrared air-to-air missile has been licensed for production by various nations. Total Sidewinder program abroad amounts to $40 million, of which $10 million will go to American industry. Each of these weapon systems was ordered "off the shelf" after being in production for DOD.

STL STUDYING CURRENT BOOSTERS FOR MOON SHOTS

NASA is nearing decisions on two lunar boosters and perhaps a workhorse first stage for routine space shots.

Concluding that present space boosters, e.g., Thor-Agena and Atlas-Agena B, are satisfactory for the space mission but might be improved, NASA has told Space Technology Laboratories to study current medium-class vehicles as possible boosters for future missions. STL will take six months to check payload capabilities of current boosters and improved versions. But NASA feels a brand-new booster, designed from scratch for the space role, would be smaller, lighter and less expensive.

NASA calling Bidder's conference for Nova booster

For lunar operations, a bidders' conference will be called by NASA for October or November for the Nova solid booster, at which time specifications will be laid down. Tentative specs call for a first-stage thrust of 20 million lb, provided by eight segmented clustered engines which produce 2½ million lb of thrust each.

The first stage will be 120 ft. long, with the engine having a 160-in. diameter. Each engine will weigh 1.3 million lb; the cluster will weigh 10.1 million lb and have a diameter of 45 ft. The solid first stage is expected to burn for 100 seconds and boost an 85-ton payload to escape velocity.

NASA has already received the reports of Lockheed, North American and GD-Astronautics on design studies for the Rocketdyne F-1 liquid-powered first stage Nova and hopes to issue a hardware design contract by January. This timetable would probably delay the liquid Nova's first-stage test flights until 1964. The F-1 is expected to be ready early in 1963 but the vehicle assembly may take up to 30 months.

NAVY MAY SPONSOR MANNED ANTI-ICBM AIRCRAFT

Navy officials are considering sponsoring studies by McDonnell Aircraft which could lead to a manned carrier-launched vehicle for defense against enemy ICBMs by 1970.

McDonnell has carried on its own studies on a DynaSoar-type plane which would be used primarily for defense against enemy ballistic missiles. McDonnell believes the project is feasible and that the engine to power such an aircraft is almost within the current state of the art. A boost-glide power plant will certainly be available by 1970, the St. Louis firm thinks.

Navy officials have been concerned about defense of the fleet against ballistic missiles, but emphasis until now has been on the medium and long-range Typhon missiles for interception.

On following pages . . .

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- Ranger I destroyed on re-entry after two days in orbit 37
- Four more Rangers to be added to test series 37
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NEW DEPARTURE
MINIATURE AND INSTRUMENT BALL BEARINGS

No. 18 on Reader Service Card

PRESIDENT ORDERS STUDY OF GOVERNMENT CONTRACTS WITH PRIVATE TECHNICAL ADVISORY GROUPS

Budget Bureau Director David E. Bell has a Dec. 1 deadline for his report to President Kennedy on the effectiveness of the various technical advisory groups used by Government agencies.

Participants in the study are Defense Secretary Robert S. McNamara, AEC Chairman Glenn T. Seaborg, NASA Administrator James Webb, Dr. Jerome Wiesner, the Presidential advisor on science and technology, and Civil Service Commission chairman John Macy.

The President's request to Bell ordered him to analyze government contracts with private concerns for operation and management of R&D facilities and programs, for analytical studies and advisory services, and for technical supervision of weapon systems and other programs administered on a system basis.

Similar analyses and studies of organizations like Aerospace Corp., Rand Corp., Mitre Corp., Johns Hopkins' Applied Physics Laboratory, etc. are being conducted by Rep. Overton Brooks' House Space Committee.

Scope of Bell study

The Bell study will cover:

- Effect of these contracts on direct Federal operations, the Federal personnel system, and the Government's in-house capabilities. Bell and his colleagues will also analyze the government's ability to review contractor operations, do direct scientific and technical work in areas where outside contracts have not been used, and recommend ways to increase government capability in these areas.
- U.S. policies in setting salaries and fringe benefits for personnel working under these contracts.
- Criteria to decide whether the government should contract and internally handle new R&D situations.
- Policies governing outside contracts, and guidelines for establishing firms whose only business will be managing activities for the U.S.
- Ways to review and supervise contractors' operations.
- Policies for setting appropriate fees for contractors and appropriate cost reimbursements for overhead, equipment and advertising.

The Bell study does not necessarily indicate a forthcoming decline in the use of special-purpose concerns. The use of such companies (mostly non-profit) is well established and has provided many benefits in areas where the U.S. did not have or could not afford to hire qualified manpower.

However, the simple fact that Mr. Kennedy asked for a review of the outside-contractor program and the points he asked Bell's group to check indicates that the number of non-profit companies organized to handling special projects for the U.S. may be limited in the future.

NASA WILL ASK CONGRESS FOR $100 MILLION SUPPLEMENT

NASA will request a supplemental appropriation of about $100 million after Congress reconvenes in January. Members of the House and Senate Appropriations Committees are expected to provide the cash without an argument.

Appropriations groups had cut money

The extra money was deleted by the appropriations groups after the two Space Committees had approved the full sums requested by the President—$1.784 billion in the Kennedy revision of the Ike budget and an additional $549 million sought in May to shoot for the moon by 1970. Total reductions amounted to $112 million less than the Space Committee recommended.

When NASA Administrator Webb appeals for the supplemental, the Space Committees' previous authorizations may even eliminate the need for additional testimony. In any case, the added $100 million will be approved with no trouble.

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No. 19 on Reader Service Card

RANGER I DESTROYED ON RE-ENTRY AFTER TWO DAYS IN ORBIT

Ranger I, which failed to go into its planned deep space orbit and instead took up a low earth orbit, was destroyed on re-entry after circling the earth for two days. The booster was a modified Atlas D, with an Agena B as second stage. Ranger had eight sets of instrumentation for experiments in solar radiation, particle detection, cosmic rays, magnetic fields, solar X-rays, neutral hydrogen geocorona, cosmic dust and friction in space.

The friction experiment was the only one not concerned with either particles or radiation. The evaporation of metals in space has the effect of super-cleaning them, causing many of them to stick together by molecular adhesion. NASA scientists hope to find combinations of metals for bearings that can work against each other under space conditions, for use in mechanical instruments for spacecraft.

Four more Rangers to be added to test series

Four more vehicles, Rangers 6-9, will be added to the Ranger test series, according to Dr. Robert Seamans, Jr., NASA's associate administrator. The announcement was made at a joint conference held at Jet Propulsion Laboratories, Pasadena, Calif., by JPL and NASA officials. The new vehicles' main mission will be to take TV pictures of the moon's surface. The landings will be hard impact, with the cameras taking pictures right up to the moment of impact.

Although Ranger 1 failed to go into the desired orbit, it did provide most of the data wanted from the tests. The re-start of the Agena B did not provide enough 'kick' to move the Ranger into the deep space orbit. However, both sun and earth sensors from the Ranger control system locked onto the desired targets, thus proving out the system. In addition, all the instrumentation systems aboard worked properly. All data, the conference was told, indicated that the Ranger design worked as intended, greatly increasing hopes for a successful lunar landing in 1962.

The Cape Canaveral rocket center will be quintupled in size to make room for launching and support facilities for manned moon-flights and other advanced missions. The enlargement will take place in the areas west and north of the present base. Launch pads for the huge boosters, developing up to 20,000,000 lb lift-off thrust, will be built at the water's edge. There will be a ten-mile strip of land between the pads and the nearest populated areas.

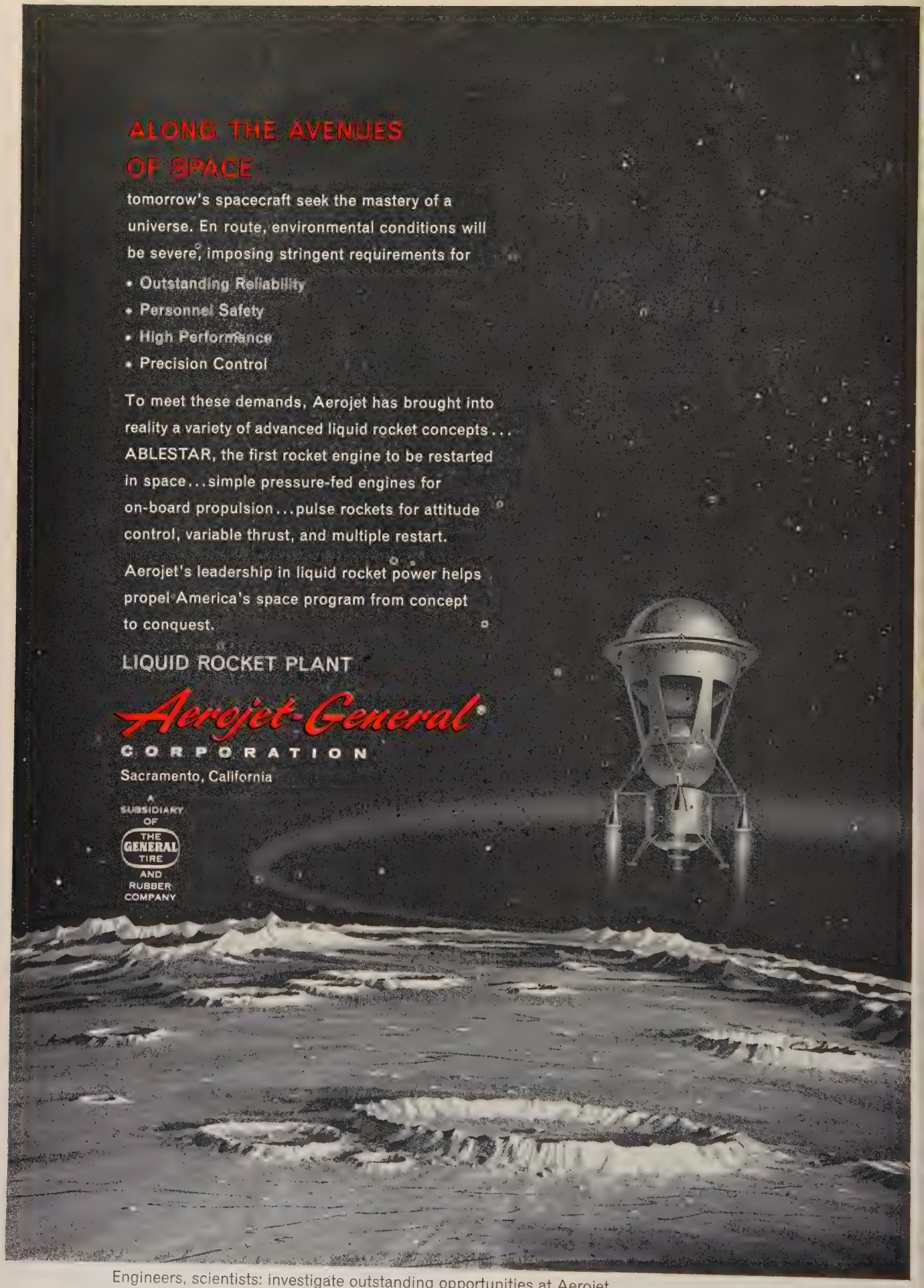
TWO MORE SUCCESSFUL TITAN FLIGHTS

Titan ICBMs made successful flights two days in a row. The first, which went 6,100 mi down the Atlantic Missile Range, was an operational prototype using a ground command guidance system. The next day a 5,000 mile trip was made to check the inertial guidance system scheduled for service in the Titan II. The flights made a total of 29 successes in 39 firings.

Pilots complete simulated space flight

Two AF pilots completed a 17-day simulated space flight at the Aerospace Medical Center, Brooks AFB, San Antonio, without any ill effects from breathing the pure-oxygen atmosphere. The pilots, Lts. Joseph H. Slider and Bernard Appel, spent their time in the sealed tank taking care of their personal needs, resting, and operating a behavior simulator designed to test their alertness. The test was the third in a series to study various aspects of manned space flight.

Static firing of 1.5-million-lb-thrust F-1 engine was witnessed by the press this month. Firing was one of a series gradually building up to rated thrust of 1.5 million lb and firing time of 2½ minutes. In first firings, thrust of one million pounds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was reached. In earlier subsystem tests, the thrust chamber reached a record 1.64 million lb, the F-1's manufacturer, Rocketdyne, reports. Possible uses of F-1 in NASA Nova program program include a booster of four clusters of two F-1s to provide 12 million pounds of thrust, with a second-stage cluster of two F-1s.

CRYOGENIC STRETCH-FORMING METHOD FOR METALS

The Ardeform metal-working process was unveiled by Arde-Portland Co. of South Portland, Maine. Essentially a cryogenic stretch-forming method performed at —320 deg F, it is based on the principle that cold working at such temperature markedly improves the room-temperature strength of austenitic stainless steels.

An undersize vessel, called the preform, is made as the first step. For cylindrical vessels, annealed sheet stock is used in the as-received sections. Roll and weld methods can be used, but good quality welds are needed to permit the sizable stretching—up to 13 per cent in diameter—that takes place. Preform is then placed inside a stainless-steel forming die in the steel-forming tank and clamped to the tank to prevent floating. The tank is filled with liquid nitrogen and sealed off, except for a pressurizing line leading to a supply of compressed nitrogen gas. The gas is used to expand the preform. After stretching, a vent is opened to release pressure and the vessel is removed. With such materials as Type 301 stainless, Arde-Portland states, the process has increased nominal tensile strength from 102,000 to 260,000 psi. Within a year, tensiles of 380-400,000 are expected to be reached.

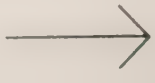
Stationary jet-engine starter system

Installation of a new stationary jet engine starter system at Western Airlines service facility at the new Salt Lake City, Utah, airport was announced by Greer Hydraulics. The system, designed by Greer and Atlas-Copco of Sweden, includes a completely self-contained unit, called the Air Partner, to provide a continuous supply of warm, oil-free compressed air for driving the air turbine starters on jet and turboprop aircraft. Air Partner consists of one rotary, twin-screw positive-displacement compressor, made by Atlas-Copco, driven by a 250-hp electric motor. Compressed air is delivered through ducts to eight hydrant stations along the concourse of the Western Airlines service area. Each hydrant station has controls for starting and stopping the main unit, and pressure gages and a "blow-down" switch for unloading the air circuit. Western reports using the system for some 60 hr per month without maintenance problems.

The Air Force reports a new method for making wide, flat, thin profile aluminum extrusions using a rectangular (flat) billet container instead of the usual round container in the conventional extrusion press. This approach is claimed to allow extrusion of thinner metal sections and greater unit pressure to provide more efficient metal flow. In tests with both 6063 and 7075 aluminum alloys, the new method allowed an extrusion pressure of 109,000 psi on the billet. In one case, an integrally stiffened panel of 7075, 18 in. wide with web thickness of 0.037 in. and eight stiffeners, was successfully extruded to a length of 25 ft, with excellent surface condition. Extrusion rate for 7075 was 2-4 fpm, for 6063, 6-10 fpm.

HALF-MILLION-LB SOLID ROCKET FIRED

A half-million-lb, segmented soil-propellant rocket was fired successfully by Aerojet-General at Sacramento, Calif. The unit was 8⅓ ft in diameter and made up of four segments assembled at the test stand before firing. The motor was the fourth to be fired by Aerojet under the USAF's large solid rocket motor program. The firing re-used the steel case of the center segment which saw service in the previous solid test. Aerojet officials said, "The tremendous heat inside the first 100-in. motor of over 5000 deg F did not even scorch the paint of the center segment, so we refurbished it and reloaded it with propellant."



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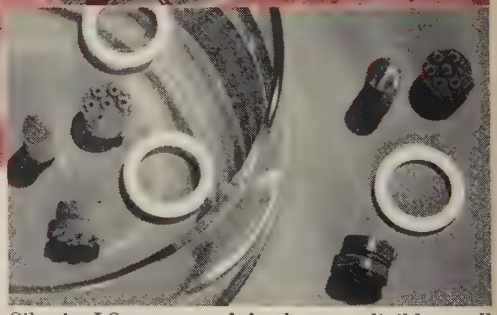

Silastic LS parts at left show negligible swell after prolonged immersion in JP-4 fuel. Identical parts at right were not immersed.

Here's why Silastic® LS is specified to seal jet fuel in . . . trouble out

Seals that come into contact with jet fuel must always perform as if they are *brand new* . . . installed only moments before take off on today's intercontinental jetliners.

Chances are, however, these seals have been in use for months. Hundreds of hours of *over-the-weather* flying have exposed them to the attack of ozone. Minutes after take off these seals can plunge from oven-like runway conditions to high altitude temperatures of —60 F. Yet, despite repeated thermal cycling and exposure to rubber-killing conditions, these seals must maintain their integrity . . . exhibit no evidence of cracking or checking. They must remain flexible in the bitter cold at high altitude to assure completely reliable operation . . . and, though they are in constant contact with jet fuel, resist swell and tenderizing.

When you study the photograph and chart of properties at right, it's easy to see why Silastic LS, the fuel-resistant silicone rubber is specified as standard material for many jetliner seals.

PROPERTIES CHART

Physical Properties	
Hardness, (Shore A)	50-65
Tensile Strength, psi	800-1000
Elongation, percent	150-170
Brittle Point	—90

Fuel Resistance (JP-4)

	Durometer Change	*Tensile Str'gth Change %*	*Volume Change %*
After 30 days immersion	—5	—31	+10

Weather Resistance	
After 31 months (3549 sun hours) at Florida Test Station	no visible effects

For information about Silastic LS and a list of part suppliers, write Department A322, Dow Corning Corporation, Midland, Mich.

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Self-propelled atomic power unit proposed for Spur project

A self-propelled space power unit for nuclear Spur project was proposed to Air Force by AiResearch Mfg. Div., The Garrett Corp., prime contractor for Spur. A typewriter-size atomic reactor will be used to heat and expand liquid metal through a turbine to generate 300,000 to one million watts of electricity over a 1-3 year period. Garrett proposes to apply this power to ion motors using cesium to move the unit to its final location in space. Use of extremely high loop pressures will make Spur the first large-output space power package of practical size and weight for missile launching, AiResearch reports. Spur will weigh eight pounds for each 1000 W of power produced. Ground prototype test is slated to start in early 1966.

Convair 990 flight tests indicate the plane can be operated at heavier landing weights than originally planned, General Dynamics/Convair reports. The craft will be certified for landing weight of 202,000 lb, an increase of 22,000 lb. Also announced was an increase in max takeoff weight from 239,200 to 244,200 lb to give the domestic 990 a takeoff weight identical to the 990 Coronado Intercontinental versions.

EXPLORER XII STUDIES ENERGETIC PARTICLES

Explorer XII satellite, successfully orbited by Douglas-NASA Delta vehicle, was first of a NASA series to study the behavior of energetic particles (protons and electrons). The program consists of six tests: cosmic ray, proton analyzer, ion electron detector, solar cell, magnetic field and trapped particle radiation. A Goddard photocell optical system furnishes data on the satellite's orientation in space. The energetic particle satellite launched on Aug. 15 weighed 83 lb and included 10 particle-detection systems.

The satellite is an octagonal-walled platform of nylon honeycomb and fiberglass with an 0.020-in.-thick aluminum cover. Octagon height is 5½ in.; width across the flats of the octagon is 26$\frac{5}{32}$ in. A transmitter in the base of the payload allows heat to dissipate through the structure and aluminum cover. Spring-loaded solar paddles which extend from main structure have an area of 3.84 sq ft and max diameter of 60 in. in orbit. Paddles are 13.68 in. long and 20.18 in. wide Thirteen silver-cadmium storage batteries weigh 11 lb and provide 15 W of power. Solar paddle wheels provide five watts. Two watt, 136 megacycle transmitter provides 50 samples of telemetry per second.

Liftoff weight of Thor-Delta was 112,000 lb. Desired orbit—180 statute miles perigee and 47,800 miles apogee—was achieved, providing an orbit that cuts through both inner and outer rings of Van Allen radiation belt. Inclination is 33.3 deg and period 26 hr, 25 min. Estimated lifetime is one year.

Explorer XIII was successfully orbited on August 25 by solid-propellant Scout vehicle. Stages were: Algol, first; Castor (modified Sergeant engine), second; Antares (scaled-up version of fourth stage), third; and Altair, fourth. Liftoff weight was 36,600 lb; vehicle height, 72 ft; and base diameter, 40 in. Orbit had perigee of 174.6 miles and apogee of 606.34. Inclination was 36.42 deg and period 97.27 min. Payload weight was 187 lb, including 50-lb spent fourth stage and 12-lb transition section.

The cylindrical payload surface was almost completely covered by five types of micrometeorite impact and penetration detectors. These included: pressurized cells of various thicknesses, foil gages (printed circuit mounted underneath stainless steel samples, wire grids, cadmium sulfide cells and piezoelectric crystal impact detecting transducers. Two separate transmitter-telemetry circuits operate on 136.86 and 136.2 mc.

Solar stabilizer for attitude control

A passive solar stabilizer concept for spacecraft attitude control was proposed to Fourth Western Meeting of the American Astronautical Society in San Francisco, Calif. by R. L. Sohn and R. G. Stern of Space Technology Laboratories and Aerospace Corp., respectively. The device uses the ejection of gas particles from the

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SERIES 3064
20 lb. thrust at 2"/sec.; Adj. stops; Size 4.5 x 14.5 x 2.3.; Wt. 7.5 lbs.

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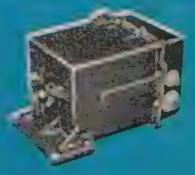


SERIES 3079
Torque 175 lb-in. at 25 rpm; Compact 11.25 x 6.87 x 8; Wt. 14 lbs.

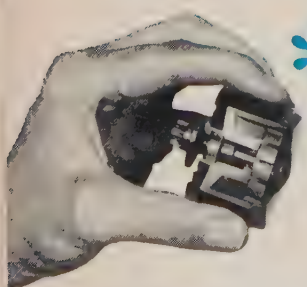
SERIES 3061
Torque 500 lb-in. at 11 rpm; Size 2.6 x 6.97 x 6.87; Wt. 7.45 lbs.

SERIES 3162
20 lb. thrust at 1.3"/sec. Wt. 19 oz. Size 3 x 3 x 3½. Position feedback.

SERIES 1377
Torque 40 lb-in. at 75 rpm; Wt. 6.5; 4.5 x 6.5 x 3.5; USAF AFC Servo.

SERIES 3170
Size 2 x 2 x 3; Wt. 15 oz; Torque 1-70 lb-in. at 285-4.6 rpm; Freq. resp. 30 cps with 90° phase shift.

SERIES 3156
Torque 400 lb-in. at 26 rpm. Four output axes. Size 16.5 x 10.5 x 4.8.



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surface of weathervane-type stabilizers to provide needed force. Some of the gas particles come from the stabilizer surface itself, which evaporates when heated directly by sunlight. Since this evaporation source is small, hydrogen gas would have to be diffused through the stabilizer surface from an internal reservoir. Sohn and Stern suggest a typical stabilizer to be made from a honeycomb core with thin palladium surface plates. The report notes that passive gas diffusion stabilizers can produce "kick" forces several order of magnitude greater than those from radiation pressures from reflected photons. A force 0.98×10^4 times that of solar radiation pressure is estimated for the system. Actual force is 0.74 gm/ft^2. An advantage claimed for the system is the elimination of all active elements, such as gas jets or motors.

Hypervelocity re-entry data will be obtained from 'power-drive' Trailblazer II re-entry capsules being built by General Electric's Missile and Space Vehicle Dept. Payload will be for fourth stage of ARPA vehicles to be launched from NASA's Wallops Island, Va., facility. First two Trailblazer stages will launch vehicle nearly vertically, to 190 miles altitude, and final two stages will then power dive nearly straight down, at speeds of up to 17,000 mph. Re-entry vehicle will be about two feet long and weigh about 30 lb. Overall shape is conical, with a rounded nose and vehicle inner structure made from magnesium-thorium alloy to cut weight. Ablation-type nose cones will be used.

SPACE-ENVIRONMENT MODEL FOR USE WITH FLIGHT SIMULATOR

An electromagnetic model of the cislunar space environment for use with a flight training simulator was presented to the AAS Conference by W. A. Livingston and E. Hart of Cornell Aeronautical Laboratory, Buffalo, N.Y. The model considers two radiation bands: those influencing communications channels and those affecting the craft's thermal balance. Probable frequency band for the first lies between 100 mc and 15 kmc, they state, and for the latter between 0.2 and seven microns. Only a few of the many radiation sources in space, they point out, are of sufficient intensity to justify inclusion in any but a very detailed model. Sources of RF radiation considered are the galaxy, sun, earth and moon. Sources of thermal radiation are the sun, earth and moon. The sun, say Livingston and Hart, is the only object in the solar system having an independent source of energy. Radiations from both earth and moon are composed of reflected solar radiation and thermal (i.e., black body) radiation, the thermal radiations being sufficient to maintain the heat balance of earth and moon.

High-temperature composites for advanced systems

Composite high-temperature structural programs being pursued by USAF's Aeronautical Systems Div. for advanced systems encountering temperatures of 2500-4500 deg F were discussed by R. D. Guyton of WADD at the recent AFOSR Conference on Aerodynamically Heated Structures, held at A. D. Little, Inc., Cambridge, Mass. In ceramic systems, particular emphasis was placed on composites using foamed zirconia, alumina and silica. Systems discussed included foamed-in-place ceramic in an open-faced honeycomb and flexible bonding supports. Advantages of materials like beryllium in composites and work in this area were described to the meeting. Guyton noted that large scale efforts are being planned for flight-test evaluation of several types of thermal protection systems.

First model of its segmented, soil propellant "Big Booster" rocket motor has been fired by Grand Central Rocket Co., Redlands, Calif. The model is the first step toward development of multi-million-pound-thrust designs. The test motor was three feet in diameter, contained about 2½ tons of propellant, and produced an average thrust of over 30,000 lb. It consists of three segments, a central cylindrical section and two end segments.

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MEN BEHIND THE CONTRACTS

Nielsen

"Furthering the art of phaselock systems"

AN ADVANCED S-band communications system for space-vehicle tracking stations is being designed and built by The Siegler Corp., Hallamore Div., Anaheim, Calif., under a $500,000 contract from JPL, CalTech.

Project engineer Carl L. Nielsen, manager of the company's development department, describes the equipment as "furthering the state of the art of phaselock communication systems." Engineers have been transferred from other Hallamore proprietary projects to work on the system.

"The program will use advanced packaging concepts designed to exceed requirements of military spec Mil-1-26600," Nielsen says. "The development will result in a flexible modular system, adaptable to production quantities as required by JPL for a world-wide deep-space tracking net," he added. Hallamore is using Pert techniques for controlling the program.

Nielsen earned his BSEE at University of California in 1950, and did graduate studies at UCLA.

What happens when you hurl precise optical system into space?

WHAT HAPPENS to large, highly precise optical systems when hurled into space? For a million dollars, Itek Laboratories, Lexington 73, Mass., is going to find out.

The contract was awarded by Aeronautical Systems Div., Wright-Patterson AFB, Ohio. The work, part of the advanced research program developed by ASD, will be carried out in Itek's new optical and engineering facility, as well as in the company's large environmental test lab. The project will extend over 18 months.

Dr. F. Dow Smith, director of the Lab's Graphic Information Research Div., says the immediate goal of the program "is to establish criteria for the future development of optical systems which not only can withstand the effects of the severe new aerospace environment, but which also can produce images of unprecedented clarity. The work," he explains, "will include extensive study of the effects of such factors as extreme temperature changes, vibration, launching shock, and high-energy radiation."

Much of the test equipment and many of the techniques to be used have evolved from the company's work on contracts in the photo recon field. Simulated aerospace environments will be created by the company's specialized testing equipment in its environmental lab.

"The operational requirements are such that the precision in optical equipment which we foresee will be more that of large astronomical telescopes than that of classical aerial cameras," Dr. Smith says.

Stone

Plans to add 80 engineers

ENGINEERING design facilities are being expanded by about 20 per cent at Kaman Aircraft Corp., Bloomfield, Conn. Space added will be about 5400 sq ft. Kaman now has nearly a million square feet divided between its Bloomfield, Hartford, and Moosup plants.

Kaman plans to add 80 engineers and scientists in aerodynamics, dynamics, electronics, stress, weight control, materials engineering, and mechanical and airframe structural design.

Walter N. Stone, vice president and chief engineer, says the "new space will enable Kaman to spread out and improve working conditions in existing facilities, and to continue to make additions throughout our engineering staff. We have always had room on the staff for qualified men," he explained to SPACE/AERONAUTICS, "but physical space sometimes presented a problem which these new accommodations will help solve.

Stone has racked up 22 years of experience in design, development and process development in the aerospace industry. He is a graduate mechanical engineer with the degree of BME cum laude from New York U.

"The recent interest in VTOL," he explains, "points up the fact that our industry is at the point of being able to design a spectrum of aircraft between the pure copter and the high-speed VTOL to match the design requirements of any particular operation."

Lapham

Typhon missile development project manager

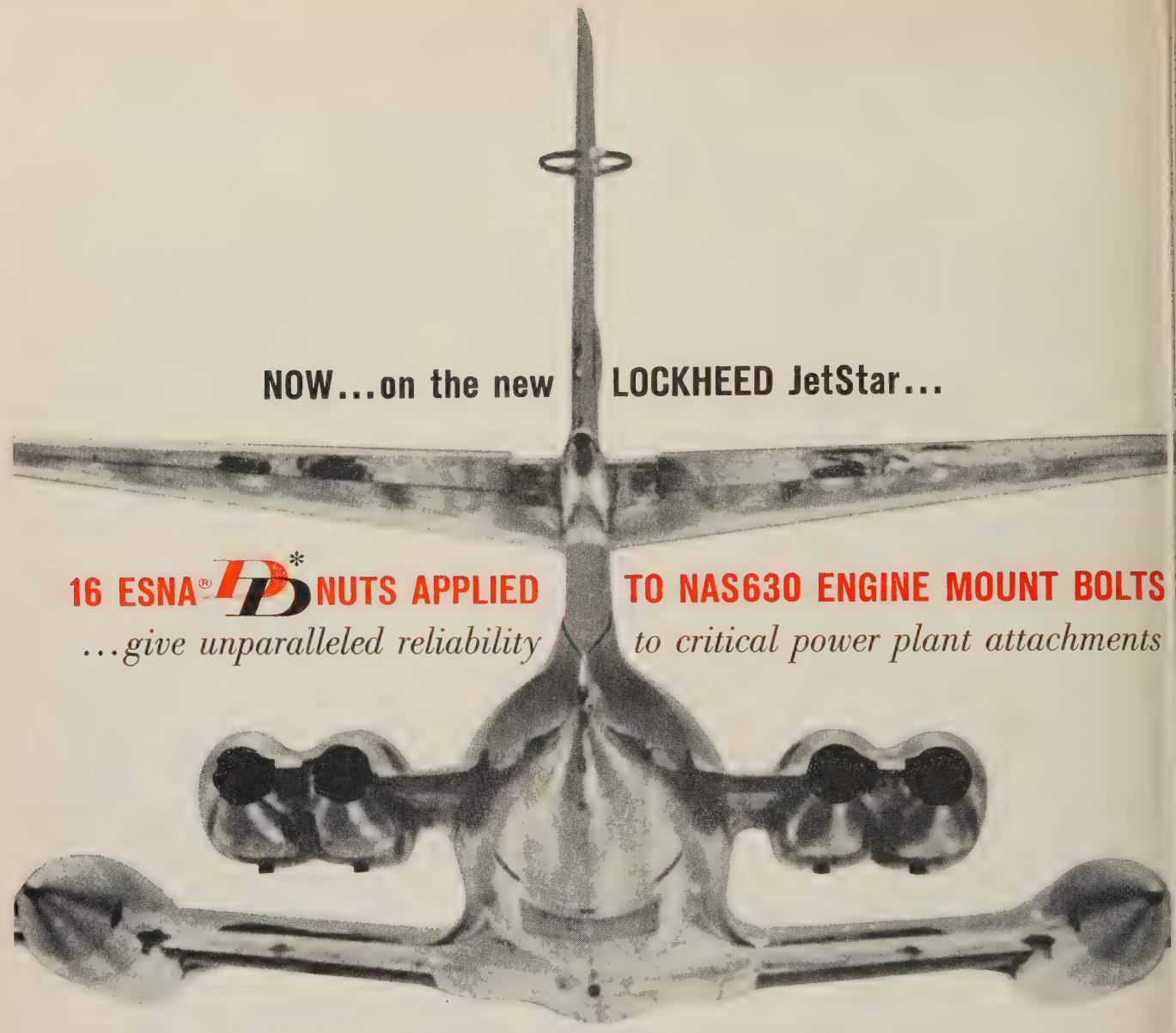
THE TYPHON long range missile development contractor and "team mates" have been selected by Navy. Bendix Mishawaka Div., The Bendix Corp., Mishawaka, Ind., is the contractor on the missile team. The amount of the contract is still being negotiated, but is expected to be between $30 and $40 million.

The Applied Physics Laboratory, Johns Hopkins, did the preliminary design work and will be overall systems director.

E. F. Lapham is Bendix Typhon project manager. Lapham, who has a BSEE, Northeastern College (1942), will be responsible for technical quality, schedules and cost. He using the Talos engineering team, although the organization will be altered for the new project.

The Typhon systems, when developed, are expected to provide the fleet with a greatly improved anti-air-warfare capability, plus an offensive capability for engaging enemy fleet units.

The system should "greatly extend the range and improve the



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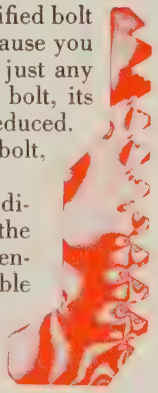
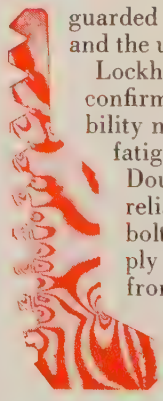


OLD



NEW

Lockheed engineers design for reliability, and tests confirmed ESNA data showing that Double/Durability nuts could be depended upon to increase the fatigue life of the JetStar power plant attachments. Double/Durability nuts can provide the kind of reliability insurance you want for your critical bolted connections. In fact, they actually multiply the fatigue endurance of high-tensile bolts from 2 to 30 times! Write for Design Manual 5930—with complete photo-elastic studies and data. Dept. S61-1050, Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, N. J.

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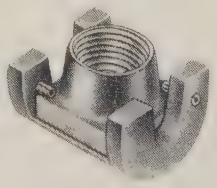
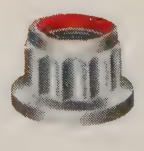
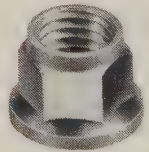


LH2577T, (180,000 psi)
LH3220T, (220,000 psi)



EBT,(180,000 psi)



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accuracy, target-handling capacity, and quick reaction capability of future guided missile warships," the Navy said. When launched from the warship, Typhon will intercept both enemy aircraft and missiles at great ranges from primary fleet targets.

Hartman

Designing subminiature cermet element resistors

SUBMINIATURE cermet-element variable resistors are being designed and developed by CTS Corp., Elkhart, Ind., under a $238,767 Army Signal Corps contract. Clinton W. Hartman, CTS director of research, heads the program.

Hartman, who has a BS in chemical engineering from Purdue, says the two-year contract calls for design, tooling, pilot production, qualification testing and a reliability study of the resistors. An engineering analysis and production planning study will also be made.

The cermet film consists of a metal-ceramic composition fused to a ceramic substrate at temperatures above 600 deg C. It is extremely stable at high temperatures and severe environmental conditions, Hartman says.

Beyond-the-horizon propagation principles

DESIGN, engineering and installation of an Army communications system, including microwave and tropospheric scatter, is being undertaken by Philco Corp., Communications Systems Div., Fort Washington, Pa.

The project manager is Marion Speights. The $4,746,525 contract is under the technical monitorship of the Army's Signal Engineering Agency.

According to Mr. Speights, the system will provide voice and teletype transmission by means of wide-band radio multiplexing. This system uses beyond-the-horizon propagation principles, so repeater stations may be separated by distances greater than those in line-of-sight communications. Interconnecting these radio links in tandem, he explained, allows reliable communications over thousands of miles.

Engineering and management will be handled by the Communications Systems Div. The major portion of the manufacturing will be done in the Philadelphia plant of the Communications & Weapons Div. Specialized manufacturing will

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Using Pert on rocket-borne communications system

A ROCKET-BORNE communication system to deliver messages of vital military importance to outlying USAF bases will be developed by The Bendix Corp., Bendix Systems Div., Ann Arbor, Mich. The $8-million AF project is directed by Walter A. Lyman, assisted by C. C. Mezger, systems engineering manager; M. E. Donnelly, systems integration manager, and J. B. Camp, field test manager.

Pert (*p*rogram *e*valuation and *r*eview *t*echnique) is being used as a scheduling and planning tool. "From previous experience with Pert," Lyman told SPACE/AERONAUTICS, "we believe in its use as an integrated part of the program scheduling, planning and control rather than as an auxiliary or peripheral technique."

The program is managed by the 480-L Systems Program Office, Electronics Systems Div., Hanscom Field, Mass.

Can a magnethydrodynamic engine be used in space?

A PROJECT to find out whether a magnetohydrodynamic (MHD) engine can be used for propelling vehicles through deep space is being conducted by General Dynamics/Convair, San Diego, Calif.

The $98,264 NASA contract is a year-long project under the direction of Dr. Ralph Lovberg. Dr. Lovberg is working in the Convair physics section on leave from Los Alamos Scientific Lab.

The MHD engine operates on the principle of plasma propulsion. The thrust force is achieved by applying a powerful magnetic pressure to minute quantities of ionized gas in an accelerator chamber. This pressure accelerates the gas and expels it at high speed from the exhaust end of the chamber, creating thrust.

The Convair experiments are expected to lead to a highly efficient plasma propulsion unit, Dr. Lovberg says. The ejected ionized gas will have a velocity of 60 miles per second in repetitive pulses up to 10,000 a second, he adds, and the device may produce up to a pound of thrust.

Kastelowitz

"Developing advanced and improved techniques"

A NEW half-million dollar manufacturing research lab for developing "advanced and improved techniques" for aerospace system production is now operating, Republic Aviation Corp. reports from its Farmingdale, N.Y., plant.

Believed to be the largest facility of its kind in private industry, the lab includes such units as a $75,000 one-of-a-kind tungsten inert gas welder. Another welding unit uses a high-powered electron beam gun that generates about 6000 F of heat.

Heading the new facility is the man who developed the basic concept of optical tooling, Adolph Kastelowitz who started at Republic 20 years ago as a tool maker. Continuing his education while at Republic, he advanced to his present post of director, manufacturing research department.

The main function of this department, says Kastelowitz, is to "originate, evaluate and develop processes for the use of new or existing

Tailoring protection for a "hot-spot"

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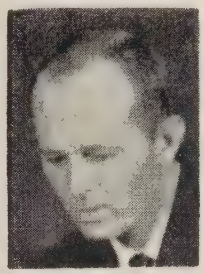
aterials in the design and produc-on of aircraft and aerospace ve-icle structures."

Some of the findings of the ma-rials lab are reported to industry, the case of service-sponsored ontracts, or through industry sur-eys and reports made by nonprofit rganizations or trade publications.

Kastelowitz has 56 engineers, 22 echnicians and 14 administrative eople working in the unit. About 5 per cent of the research effort directed toward future require-ents, and 25 per cent toward cur-ent process improvements and cost eduction, Kastelowitz says.

Strickland

"New olid propellant can be cast"



NEW solid-propellant ballistic ac-uator for the Titan II missile silo rogram will be produced by Talley ndustries, Inc., (OTC), Phoenix, riz. Contract amounts to about 495,000.

The new solid, according to oyce Strickland, chief engineer, ses an exclusive process devel-ped by Astro-Rocket, Inc., a Tal-y subsidiary. Strickland explained at the process permits the basic gredient, ammonium nitrate, to e cast rather than extruded as in resent conventional manufacture. It contains a special epoxy resin s a binder," he added.

Unusual features of the propel-nt are: castability at room tem-erature into complicated shapes; bility to cure at room temperature r slightly above, resulting in less rain when the cured propellant cooled to room temperature; vir-ual nonflammability during proc-ssing; case bond ability; and low ame temperature.

This type of propellant has per-ormed well in static tests from -40 to 165 deg. F, Strickland told PACE/AERONAUTICS.

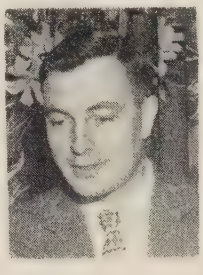
Working on third-stage Minuteman propulsion

R&D on the third-stage propulsion unit for Minuteman is being continued under a $50 million Air Force contract to Hercules Powder Co., Wilmington, Ohio. Contact also calls for delivery of flight test motors for the Minuteman R&D program at Cape Canaveral.

In charge of the propulsion R&D contract is John H. Main, manager of R&D at the Bacchus Works, where the Air Force's new Plant 81 production facility is being built. Main has a BS in applied chemistry from CalTech. He has worked in supervisory posts at Radford Arsenal, Radford, Va., at Allegany Ballistics Laboratory, and at Hercules' Bacchus, Utah, plant.

Pietenpol

"We are outgrowing our facilities"



EXPANSION of Sylvania Electric Products' Semiconductor Div., Woburn, Mass., by more than 40 per cent is under way. Dr. William J. Pietenpol, divisional vice president and general manager told SPACE/AERONAUTICS that the "division's employment is at an all-time high and we are outgrowing our facilities faster than we can plan and construct them."

Sylvania is looking for semiconductor device engineers to do advanced development or production engineering; microwave engineers for engineering on microwave diodes; field engineers to provide technical liaison between Sylvania and the customer; sales engineers to sell semiconductors throughout the U.S. Degrees in EE or physics are preferred for these jobs.

In addition, semiconductor metallurgists and chemists are wanted for handling materials such as germanium, silicon and gallium arsenide at Woburn or Hillsboro (N.H.). Degrees in metallurgy, chemistry or chemical engineering are preferred.

Sylvania's "breakthroughs in device miniaturization and epitaxial growth," Dr. Pietenpol said, "include development and production of Micro-Min diodes and varactors, tunnel diodes, 'pancake' transistors, and epitaxial versions of both silicon and germanium mesa transistors. We are working now on new multi-element miniature epitaxial techniques."

Among the advances in the state of the art: Increased power handling and density in the same device structure, better reliability, and higher cutoff frequencies and breakdown voltage.

Dr. Pietenpol, who has a BSEE, University of Colorado, earned his Ph.D. in physics at Ohio State in 1949. Formerly with RCA and Bell Telephone Labs, he joined Sylvania in '58.

Studying effects of long space missions on nonmetals.

THE EFFECTS of extended space missions on nonmetallic materials is the subject of a $52,000 NASA contract awarded The Martin Co., Baltimore Div., Baltimore, Md.

Dr. Irvin Kramer, chief of materials research, explains: "The properties of certain materials, familiar to us in the earth's atmosphere, such as the pliability of rubber, could change completely when exposed in outer space over a long period. This is a comparatively new area of research."

Two space conditions to which nonmetals will be subjected by Martin scientists are vacuum, and powerful ultraviolet radiation. In vacuum, Dr. Kramer explains, evaporation may cause certain materials to change composition. For example, a plastic may become brittle over a period of time.

Researchers also will be looking for possible changes which ultra violet light can cause. These studies will cover materials such as rubber, plastics and various synthetic membranes and insulating substances.

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Oct. 4-6 Semi-Annual Convention, American Society of Photogrammetry, Biltmore Hotel, New York, N. Y.

Oct. 9-11 National Electronics Conference, International Amphitheater, Chicago, Ill.

Oct. 9-13 National Aerospace Engineering & Manufacturing Meeting, Society of Automotive Engineers, Ambassador Hotel, Los Angeles, Calif.

Oct. 9-15 American Rocket Society's 16th Annual Meeting & Space Flight Report to the Nation, Coliseum, New York, N. Y.

Oct. 10-12 Second Conference on Nuclear Reactor Chemistry, Fifth Conference on Analytical Chemistry in Nuclear Reactor Technology, Gatlinburg, Tenn.

Oct. 11 Fall Symposium of the Institute of Printed Circuits, Sheraton-Chicago Hotel, Chicago, Ill.

Oct. 23-25 East Coast Conference on Aerospace and Navigational Electronics, IRE, Lord Baltimore Hotel, Baltimore, Md.

Oct. 24-26 International Symposium on Aerospace Nuclear Propulsion, Institute of Radio Engineers, Riviera Hotel, Las Vegas, Nev.

Oct. 24-25 Electronics Division of the American Society for Quality Control (ASQC) Sheraton Hotel, Philadelphia, Pa.

Oct. 26-27 Third Annual Symposium on High-Speed Testing, Hotel Somerset, Boston, Mass.

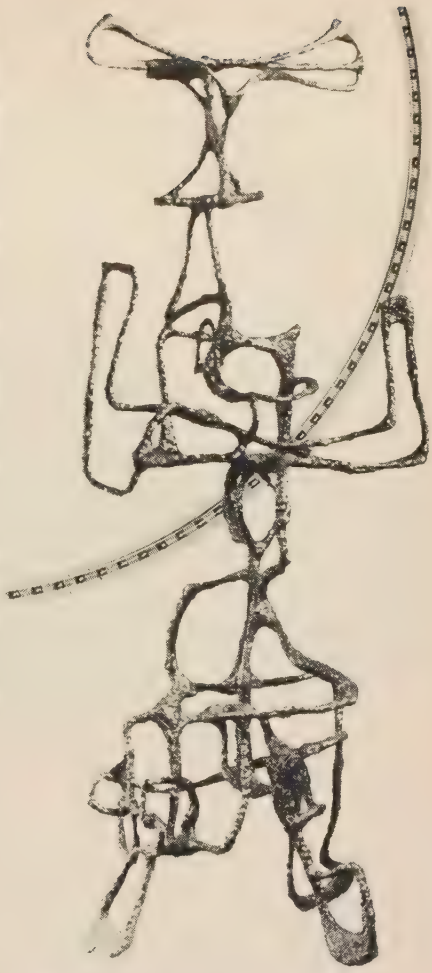
Nov. 1-3 International Conference on High Magnetic Fields, Cambridge Institute of Technology, Cambridge, Mass.

Nov. 6-8 Special Technical Conference on Non-Linear Magnetics, IRE, Statler-Hilton Hotel, Los Angeles, Calif.

Nov. 6-9 1961 Conference and Atom Fair, Atomic Industrial Forum and American Nuclear Society, Conrad Hilton Hotel, Chicago, Ill.

Nov. 9-10 11th National Conference, Aircraft and Missiles Division of American Society for Quality Control, Ambassador Hotel, Los Angeles, Calif.

Nov. 14 Electronic Systems Reliability Symposium, Kansas City, Missouri



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by **Randolph Hawthorne,** Editor

NASA views our NATIONAL SPACE GOALS

WHAT ARE our national goals in space? When you ask that question, you get almost as many different replies as there are people. Some people, in fact, frankly admit that they don't know what our goals are in space or even what they should be. Says Erle Martin, United Aircraft's vice president of R&D: "We need a clarified statement from the top, because even aerospace people just aren't able to grasp the full significance of space programs and objectives."

Some scientists outside the aerospace field grumble about the huge expense of space projects and would like to put the money into other research, especially in the life sciences. "I think we are pouring too many blamed dollars into [space exploration] and cutting other fields short," complains Dr. Vannevar Bush, famous head of the wartime Office of Scientific Research and now board chairman of Merck & Co. "A lot of people think of the Russian spaceman projects and our own as great scientific achievements. Actually," snorts Bush, "there's little scientific [value in] rushing to hurtle men into space. To me, such exploits are little more than stunts that appeal to the gladiator instincts."

Alvin Weinberg, director of the Oak Ridge National Laboratory, puts it right on the line: He believes that most Americans would rather belong to the society that found the first cure for cancer than to the one that put the first man on Mars. That Weinberg is not altogether wrong about the pulse of the public is borne out by the querulous questions from taxpayers in the letters columns of almost every daily paper as to why the billions being spent on space flight couldn't be spent better on things nearer home.

Fortunately for President Kennedy's program to place a man on the moon and return him safely, the majority of Americans is in favor of it—if only to beat the Russians. In fact, many feel that getting ahead of the Russians is our real goal in space.

But what do the top leaders of our space programs think our space goals are or should be? Are they agreed on a common objective? Does the U. S. have an official space policy, and if it does, what is it? Has the U. S. committed itself to a race with the Soviets in space?

The answers you get in Washington when you ask

IN BRIEF

If anyone has the answers to the insistent questions being asked in the aerospace industry about the real nature and value of our national goals in space, it should be the leaders of NASA, the agency in charge of most of our space programs. These men do have answers, but they are not entirely in agreement about what they think most important about our space effort.

Most of the NASA leaders, this report from Washington shows, stress the scientific and technical benefits of ambitious space programs and claim that these benefits will extend well beyond the aerospace field. There is also a minority, however, that considers victory in the race to the moon more important than anything else.

What They Say About Our Moon Program

"If we never put a man on the moon, the scientific returns of the lunar program would still be entirely worthwhile. . . . The billions of dollars required in this effort are not spent on the moon. They are spent in the factories, workshops, and laboratories of our people."

—Hugh L. Dryden

"It is essential to maintain our curiosity about things and to go ahead scientifically. We must have a goal that is far enough off. Otherwise the downward path will be taken by the country."

—Abraham Hyatt

"We can absorb about twenty billion dollars intelligently in a lunar program within the present decade. To be successful, we must make it a race. But there are races and races. We must make it a sensible race, not a crash program."

—Ira H. Abbott

"If the American worker could get the idea that his job is of vital importance to winning the race with the Reds, that would do more to improve reliability than any other single factor."

—Milton W. Rosen

these questions are somewhat inconclusive. *Yes,* there is a national objective in space—the President's program for a manned landing on the moon. *No,* there is no national overall official policy on space goals other than the very general statement outlined in the National Aeronautics and Space act of 1958. *Yes,* the leaders of our space programs share a common objective, *but* their opinions about its real significance and its benefits to the nation and mankind vary. *Yes,* the U. S. is officially in a race with the Soviets, *but* we have not committed ourselves to beating them in any specific project (and that includes manned lunar landing).

Space seen as new frontier

President Kennedy sees his moon program as part of the titanic struggle between the free world, led by the U. S., and the Reds, led by the Soviets. He has called space a new frontier, whose challenge we must meet "if we are to win the battle for men's minds." But the President cautiously refrained from saying which race we aim to win. "While we cannot guarantee that we shall one day be first," he has told Congress, "we can guarantee that any failure to share this effort will make us last. . . . This is not merely a race. Space is open to us now, and our eagerness to share its meaning is not governed by the efforts of others. We go into space because, whatever mankind must undertake, free men must fully share."

Although NASA, our top space agency, has jumped vigorously into the vast lunar program set forth by the President, its leading technical officials all stress different reasons for having the program in the first place. None contradicts the President's view of the lunar program's cold-war importance, but most of them emphasize other aspects of their effort.

Dr. Hugh L. Dryden, NASA's deputy administrator says that the significance of landing a man on the moon lies in the scientific fallout from the program resulting from this effort, not in the event itself. "If we never put a man on the moon," he told SPACE/AERONAUTICS, "the scientific returns of the lunar program would still be entirely worth while." The real values of this program, he feels, lie in the great, cooperative national effort in science and technology it is bringing forth. The knowledge we will gain from the moon program will apply in further scientific research, in communications, in meteorology, and in defense, he points out, and will strengthen our industrial base and serve as insurance against technological obsolescence.

"The billions of dollars required in this effort," Dryden emphasizes, "are not spent on the moon. They are spent in the factories, workshops, and laboratories of our people for salaries, for new materials, and for

supplies, which in turn represent income to others."

Dryden also believes that, because of its difficulty, our moon program serves the highly important function of speeding up the development of our space technology and science. It makes engineers and scientists engaged in it move forward with urgency and integrate their efforts in a way that could not be achieved by a disconnected series of research studies.

Abraham Hyatt, NASA's director of program planning and evaluation, says that our national space goals are spelled out in the 1958 act that set up NASA and in the President's announcement of our lunar program, and he can't see why anyone in the industry should need to ask what our goals are. He believes that the 1958 act is clear enough in requiring that NASA exploit the earth's atmosphere and outer space for peaceful purposes, provide aeronautical and space research support to the armed services, and in setting as general objectives the preservation of the U.S.'s role as leader in aeronautical and space science and technology and the application of aerospace technologies to peaceful activities within and outside the atmosphere.

Hyatt agrees that a significant prestige factor is involved in our space effort. What is truly important in his opinion, however, is that we "maintain our curiosity about things and go ahead scientifically. We must have a goal that is far enough off. Otherwise the downward path will be taken by the country."

Ira H. Abbott, NASA's director of advanced research programs, says our goal in space is a general one—to make use of space. More specifically, we have no goals for the near future, except for communications, weather, and other "applied" satellites.

Getting to the moon is important, Abbott believes, because man must get there if he is to do anything in space. And man is needed in space, not just his instruments, because he'll always do a better job of handling the unknowns.

Space programs advance knowledge

Abbott agrees with Dryden and Hyatt in his high opinion of ambitious space programs as levers to raise our scientific and technical knowledge.

Our moon venture, he says, will add to our knowledge in all fields, including the life sciences, home-appliance design, industrial automation, and many others. Our space effort can pace industry just as aeronautics did in the thirties and forties.

The argument that space programs deprive other scientific fields of support couldn't be more wrong, Abbott claims. "It's essentially like the labor-union attitude," he says, "that there are only so many jobs, therefore keep out progress that does away with certain types of work."

"We must keep in mind," Abbott points out, "that there is no fixed sum of money for science projects. The money that goes into space programs, or any other program, doesn't deprive other projects of money. On the contrary, when you pull up one technology or scientific area, you bring along the other fields.

"We can absorb about twenty billion dollars intelligently in a lunar program within the present decade," Abbott sums up. "To be successful, we must make it a race [with the Soviets]. But there are races and races. We must make it a sensible race, not a crash program."

In fact, Abbott sees our competition with Russia as giving us an excuse for a lunar program. He defines a sound space project as one that has enough political appeal to attract money without being too far-fetched to be technically feasible. And more important than beating the Reds, says Abbott, is to control space and therefore the earth—just as it was important for us 20 years ago to control the air.

What most troubles Abbott about our space programs is that, despite a lot of big talk about space aims, he sees no signs of a sense of urgency on the part of the people in the business. Deeds, not words, will become critical in the next year or two, according to Abbott, when the demand for funds for programs will go up sharply. "It isn't where the people put their mouths," he says, "but where they put their money that counts."

Considers victory vital

One NASA official who considers victory in the race to the moon all-important is Milton W. Rosen, deputy director of launch vehicle programs. The lunar race is immensely worth winning, Rosen explains, for being first on the moon would win us the minds of men throughout the world—and that, he agrees with the President, is what our nation's future depends on. It is vital that we maintain our technological leadership, which gradually is slipping away from us, Rosen says, not so much in actuality but in people's minds as they watch the Soviets' spectacular space feats.

An all-out prestige race to the moon, Rosen thinks, would provide the motivation for everyone involved in the effort, from the managers to the workers on the assembly lines. And the key to our winning the race, Rosen firmly believes, is motivation. Especially the people doing the small jobs must know the importance of their work. "A solder chip in a diode once lost us a rocket," Rosen points out.

"The job that isn't done well, hurts," Rosen adds. "The American worker now does not have the inner motivation to do a good job. He just wants to get his pay, go home and play golf or go fishing, or just listen to TV. If he could get the idea that his job is of vital importance to winning the race with the Reds, that would do more to improve reliability than any other single factor."

NASA obviously can't declare an all-out race to the moon. The President must do it, Rosen believes, and he can, if he wants to carry conviction, by staking the nation's prestige completely on the outcome of a race.

Are our chances of winning good enough? Rosen concedes the Reds the advantage of a shorter decision time—they do not have to debate their program in public for weeks and months on end and they do not have to take votes on every appropriation. He also points out that, as getting a man to the moon involves no new breakthroughs, there is no doubt that the Russians can do the job. On the other hand, Rosen believes that we still have the advantage of greater national resources and scientific and technical talent.

All things considered, Rosen thinks, we can win, even coming up from behind. But only if we marshal a considerable part of our industrial resources and if we really want to win—just as the Soviets want to win.

Potentially the will to win the race is there, Rosen says. Americans want to be first. They will support a leader who promises them a chance to win as spectacularly as the Reds have been winning.

But the President's objectives in the lunar program have been lost, Rosen feels. They should be repeated more forcefully, more clearly—and with a ringing declaration that we must win the race.

Re-entry systems

outgrow conservative designs

by Lawrence D. Ely, Assistant to the Manager, Office of Technical Relations, Aerospace Corp.*

JUST A FEW YEARS ago, we were wondering if we could bring a re-entry body safely back into the atmosphere at all. Now a successful re-entry seems almost a commonplace. A great many refinements have already been made in re-entry systems design, and with the third generation of the ballistic re-entry bodies in production, still further refinements are being sought.

Aerodynamic shape is one of the major factors determining the performance of a re-entry body. For ballistic missile re-entry bodies, shapes are compared on the basis of the parameter W/C_DA, where W is the weight of the body; A a representative cross-sectional area; and C_D the drag coefficient.

Figure 1 shows the basic shapes of the first three generations of ballistic-missile re-entry bodies. They are all symmetrical about the longitudinal axis and produce drag, but no lift, for air flowing parallel to the longitudinal axis. Their L/D ratios therefore are zero.

The first shape chosen for a ballistic-missile re-entry turned out to be conservative. At the time the choice was made, though, it was not even known whether it would do the job at all. What was known was that a blunt shape, because of its higher resistance, slows down

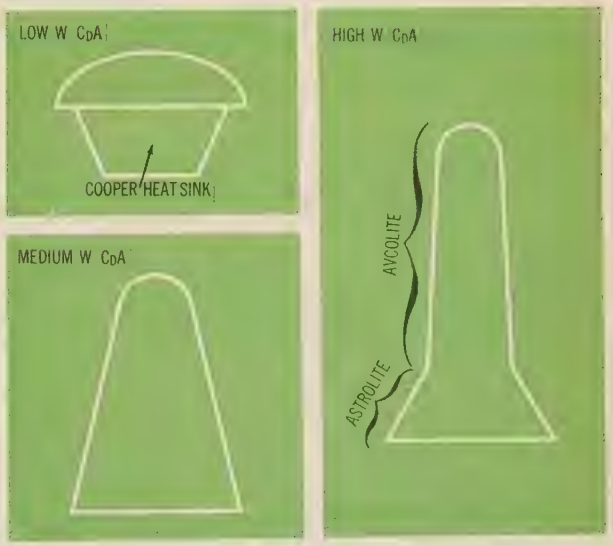

FIGURE 1: Shapes of the first three generations of ballastic re-entry bodies (top left, bottom left, and right).

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IN BRIEF

Though re-entry bodies have been in existence for a few years, they have already undergone drastic changes. Today's nose cones use ablative cooling in the place of the earlier heat sinks and have shapes considered much too radical just a while ago. In this review of current re-entry-body development, ballistic and satellite re-entries are compared and the shapes of lift-type re-entry vehicles are discussed. To save weight all our early re-entry bodies have been blunt and had zero or very little lift. Better deceleration, maneuvering and landing characteristics, though, give the lift-type re-entry body the edge for the future.

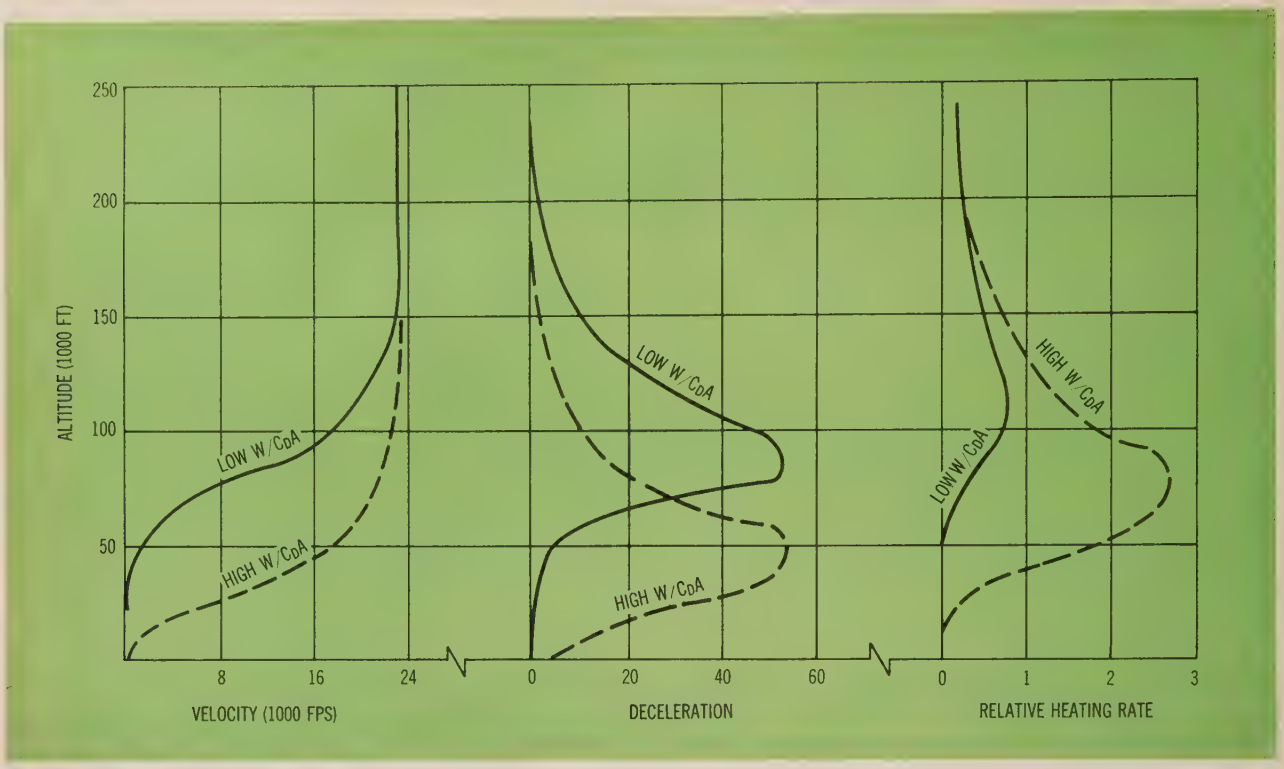


FIGURE 2: Velocity, deceleration, and heating rate of re-entry for the oldest and newest shapes of Figure 1. The deceleration curve has the same shape for both W/C_DA-values but peaks at different altitudes.

more quickly after entering the atmosphere than a more streamlined shape. It therefore loses its speed at a higher altitude and in thinner air and is subjected to less heating *(Fig. 2)*.

Figure 3 shows the effect of W/C_DA on range. Both blunt and streamlined bodies come in from space at the same velocity. Once past the upper edge of the atmosphere, the blunt body slows down more quickly and takes much longer to descend to its point of impact than does the stream-lined body, so giving an enemy more time to put up countermeasures against it. As it slows down, it comes in more steeply, achieving a little less range than the streamlined body. This loss of range is easily made up, however, with a slightly higher

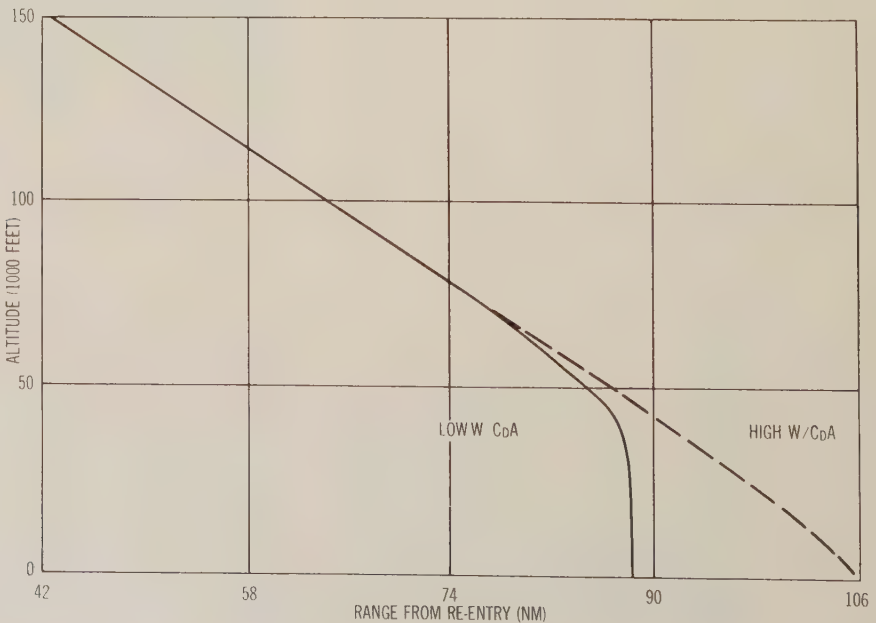


FIGURE 3: Effect of W/C_DA on range from re-entry.

burnout velocity, achieved by adding a little to either the thrust or the burning time.

Figure 4 shows the effect of W/C_DA on re-entry dispersion. As W/C_DA increases, dispersion decreases. To get the total dispersion, the guidance errors must be added to these aerodynamic dispersion values.

Figures 2-4 show that, for an operational ballistic-missile re-entry body, a high W/C_DA is would be preferable. Nevertheless, because of the heating problems and the uncertainty about the exact design conditions, the more conservative, low-W/C_DA *body was selected.* Chosen for the first generation of re-entry systems, with heating thus held to a low value, success was still doubtful, since it wasn't known whether laminar flow could be maintained. If transition were to take place, heating would rise by several orders of magnitude.

To try to keep the flow laminar, the outer surface of the body was made as smooth as possible. A heat sink was used to further hold down heating. Copper—chrome-plated to give it a smooth surface—was selected as the heat-sink material, since more information was available on the high temperature characteristics of copper than on those of other materials.

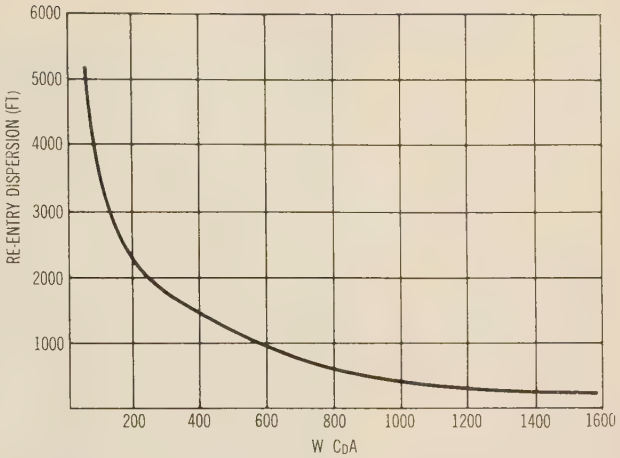


FIGURE 4: Effect of W/C_DA on re-entry dispersion (allowing for variations of wind and atmospheric density with altitude over the target area).

New re-entry shapes were considered

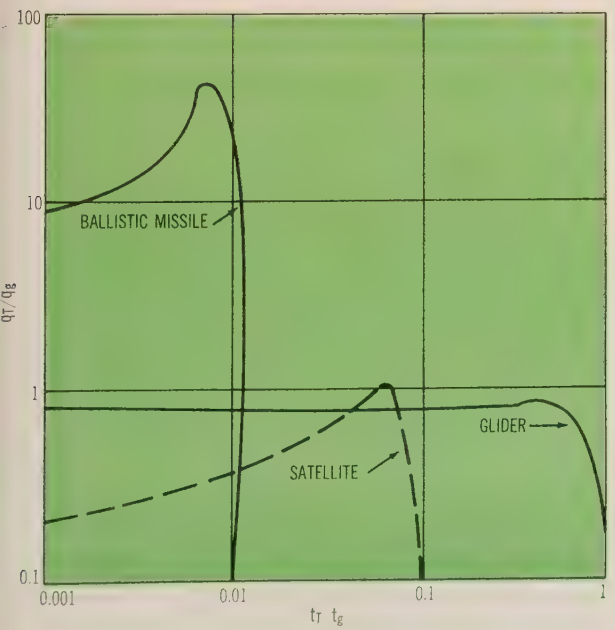
Once tests had revealed the conservatism of the blunt, solid-copper, heat-sink design, other re-entry shapes were considered. The next was the medium-W/C_DA shape of *Figure 1.* It, too, used a solid copper heat sink, but it was not so blunt. It had a lower C_D and so a higher W/C_DA. For the current design, the W/C_DA is still higher, and an ablative material is used to absorb instead of the copper heat sink.

While ballistic-missile re-entry bodies have an L/D of zero and are best compared on the basis of W/C_DA, satellite and glider re-entry bodies are best evaluated on the basis of L/D. The shapes of these latter bodies vary considerably, but the L/D ratios for satellites usually are very low, ranging from zero up to ½ or 1½, while those for gliders may be as low as 1 or as high as 10.

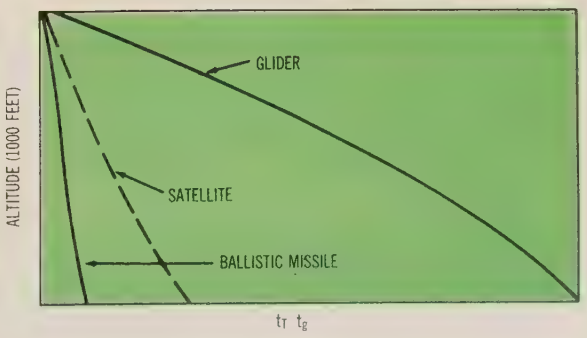
Figure 5 compares typical heating cycles of re-entering ballistic missiles, satellites and gliders. The heating rate for a ballistic-missile re-entry body is several times that of the glide body's, although the total heat absorbed by the latter is about five times that of the former.

Figure 6 shows the efficiencies of various re-entry cooling methods. This figure shows ablation methods are clearly superior for the low total-re-entry times of the

FIGURE 5: Typical heating cycles for several re-entry bodies, where t is time; Q, heat; and $\dot{q}$, heating rate; and the subscripts T and g refer, respectively, to the total re-entry from 250,000 ft to sea level and to any instantaneous value during re-entry.



	Ballistic Missile	Satellite	Glider
Q_T/Q_g	0.2	0.5	1
W/C_DA	approx. 1000	40	
W/C_LA			500
L/D			1



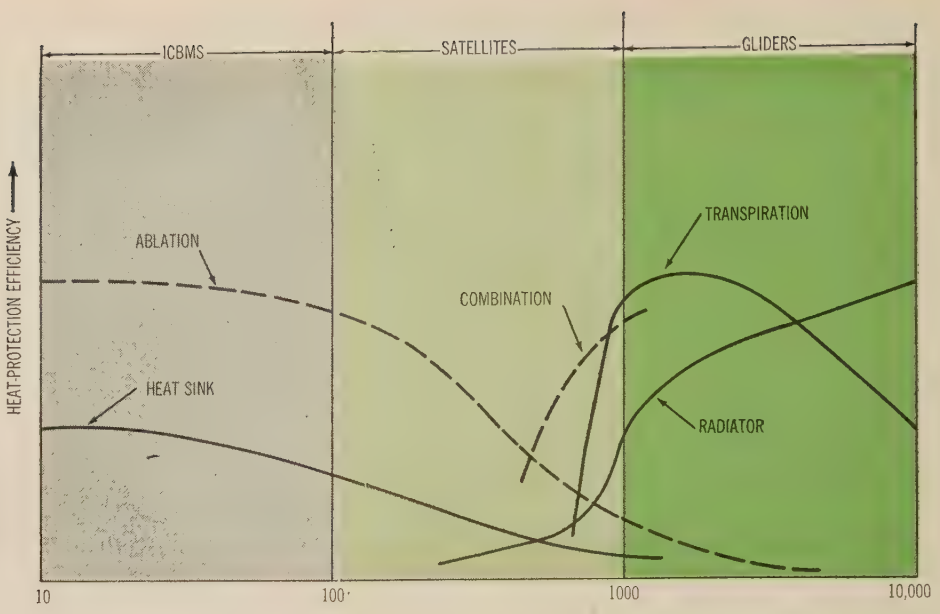
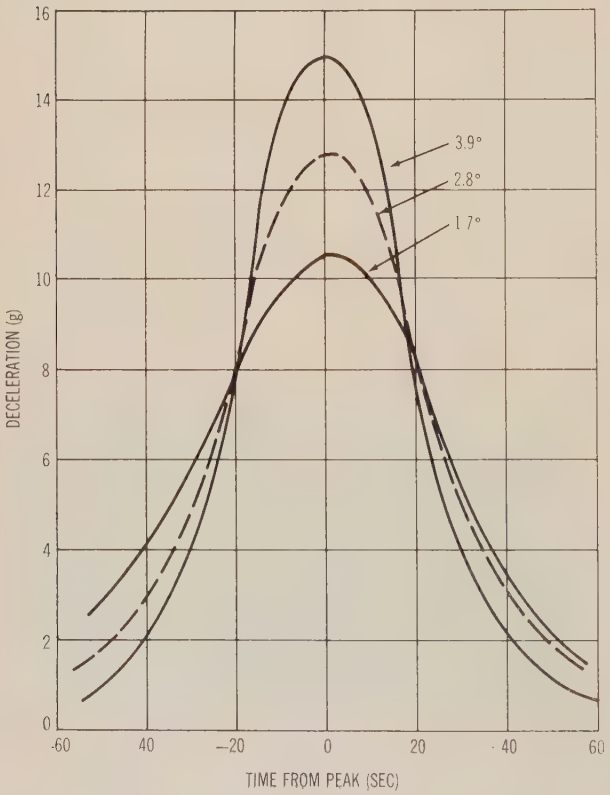


FIGURE 6: Heat-protection efficiency of four re-entry cooling methods.

ballistic missiles. Transpiration and regenerative, or radiator, cooling are unsatisfactory because of the high heat fluxes (of up to 5000 btu/sq ft) that are involved, particularly with high-W/C_DA configurations. It would be difficult to absorb the heat rapidly enough, and even if this could be done, the weight penalty would be exorbitant.

FIGURE 7: Deceleration for three re-entry angles of a satellite using drag decay or a lifting descent.



For high total re-entry times, as in the case of some satellites and glide vehicles, the ablation and heat-sink methods don't look satisfactory, and it may be necessary to go to regenerative or transpiration cooling. Material would have to be added for either ablative or heat-sink cooling and would reduce the efficiency. For certain satellite re-entry times, though, it would be hard to select an optimum cooling method, and a combination of methods may prove best instead.

Instrumentation and equipment can be designed to withstand the high re-entry decelerations of both ballistic missiles and satellites (including space probes returning via satellite orbits.) Satellites re-enter at much higher velocities than do missiles. To keep from burning up, they must therefore enter the atmosphere at very shallow angles—on the order of 2-6 deg, as against 20-22 deg for ballistic missiles. As *Figure 7* shows, the peak deceleration of a re-entering satellite increases with the re-entry angle.

Re-entry angles are highly critical

These small satellite re-entry angles are extremely critical, particularly at very high speeds. At the velocity of a re-entry body returning from a point far out in space, too shallow an angle can make the body barely graze the atmosphere and return to space, while too steep an angle could set the body on fire.

Figure 8 shows that, for any staging configuration except single-stage designs, the burnout velocity increases with the ratio of gross weight to payload—because a large part of gross weight is propellant. It also shows that the burnout velocity can be raised by staging.

Manned vehicles will use lift to reduce the landing impact of a re-entry body. Aerodynamic lift, aerodynamic drag, retro-rockets, or a combination of these methods can be used. The X-15 and Dyna-Soar are examples of winged craft using aerodynamic lift and drag. For re-entry, the Mercury and Discoverer capsules are examples of high-drag bodies using added drag in the form of a parachute.

More exotic shapes will be developed for re-entry vehicles returning from farther out in space. Most likely these shapes will provide some lift, perhaps combined

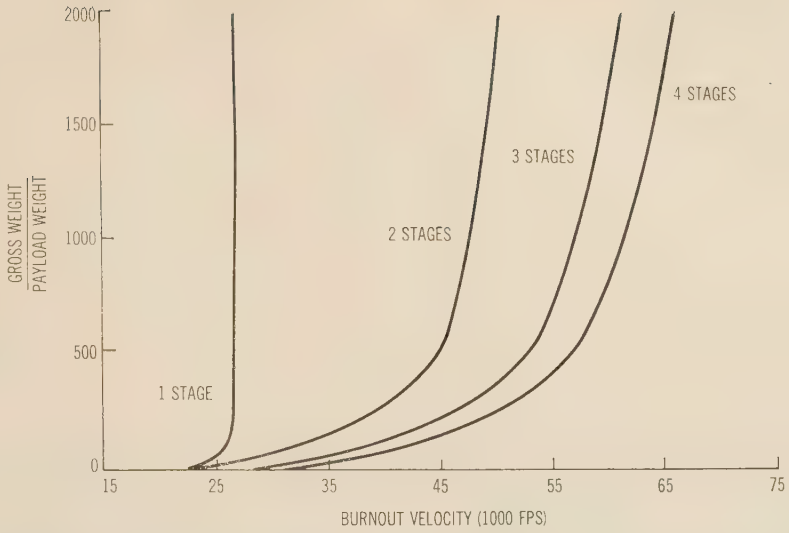


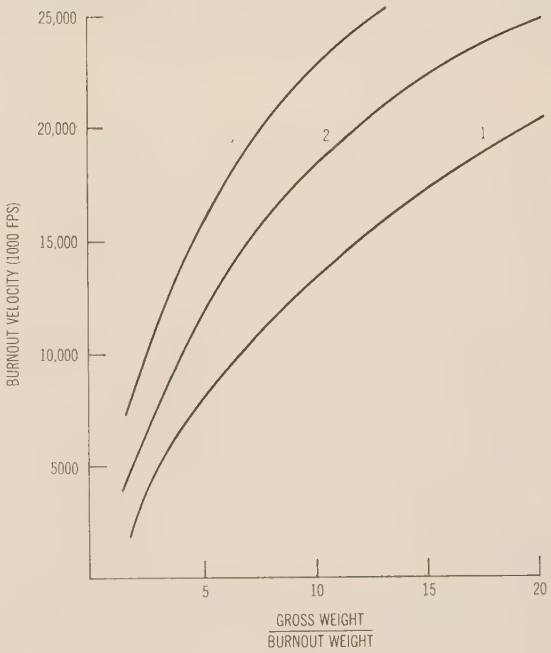
FIGURE 8: Effect of staging on the burnout velocity of a typical vehicle at a constant structural factor (percentage of gross weight represented by structure) of about 0.1 and a constant specific impulse of about 350 seconds.

with variable drag, which would offer control of the landing point and so be particularly useful for manned re-entry. *Figure 9* shows some typical shapes that might be used.

Shape C is very thin and designed for a very low weight area ratio (around three psf), so that deceleration would occur at very high altitude, in extremely thin air, and at reduced heating. Such a structure, though, represents a radical departure in design. It might prove feasible if an inflatable metal mesh could be launched while collapsed and then inflated in orbit. The other shapes have weight-area ratios ranging from 30 to 60 psf.

Blunt re-entry bodies of zero or very low lift can, in most cases, be designed and built at less weight than bodies of medium or high lift. For that reason, our earliest re-entry bodies for ballistic missiles and Project Mercury have been blunt types, even though for optimum deceleration, maneuverability, and flexibility a lift-type body should have been chosen.

The Mercury capsule gives a good idea of what we have been able to accomplish so far in the way of manned-re-entry design, given the limitations of minimum complexity, maximum reliability, and a minimum of newly developed equipment. This capsule will have a blunt front end protected by a fiberglass heat shield and an afterbody covered with corrugated cobalt-alloy shingles. Heat will be dissipated over the afterbody by radiation.



BURNOUT velocities of a typical vehicle for several ratios of thrust to gross weight at the conditions given for Figure 8.

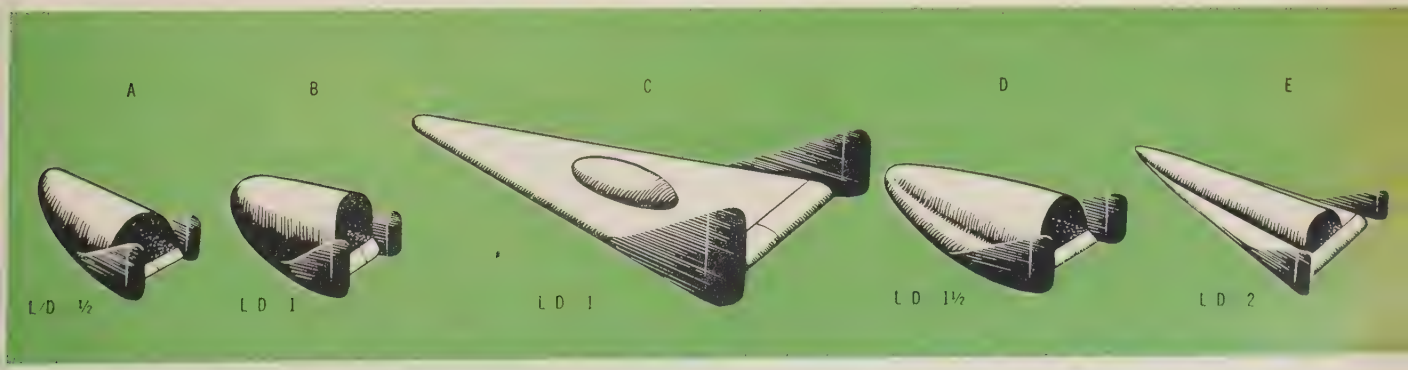


FIGURE 9: Some typical shapes for low-L/D lift-type re-entry bodies.

by Roger E. Gaumer, Head, Thermophysical Research,
Lockheed Missiles & Space Co.*

Materials for solar-energy systems

THE PHYSICAL characteristics of materials that make it possible to use solar thermal energy for spacecraft power generation and temperature control are absorptance, reflectance, and emittance. All three are determined by the condition and optical characteristics of a material's surface.

Of primary importance are the two radiation characteristics—the solar absorptance or the percentage of radiant solar energy absorbed by a material's surface (α), and the infrared emittance or the percentage of radiant energy emitted by a given surface in comparison with a black body's emission at the same temperature, (ϵ). The ratio α/ϵ is also highly significant.

In a typical solar energy conversion system (*Fig. 1*), the solar absorptance should be as close to unity as

* Lockheed Missiles & Space Co., Sunnyvale, Calif. This article is a condensation of a paper, "The Spectrum of Materials Available for the Ultlization and Control of Solar Energy," given at the UN Conference on New Sources of Energy in Rome, Italy, in August.

IN BRIEF

The basic thermophysical parameters that determine a material's usefulness for solar-energy systems and for the external heat protection of spacecraft are solar absorptance, infrared emittance, and reflectance. This survey shows how these parameters are determined, how they apply to the different elements of power conversion and temperature control systems, and compares available materials on this basis. Methods of determining the thermophysical parameters and environmental and structural factors are also discussed.

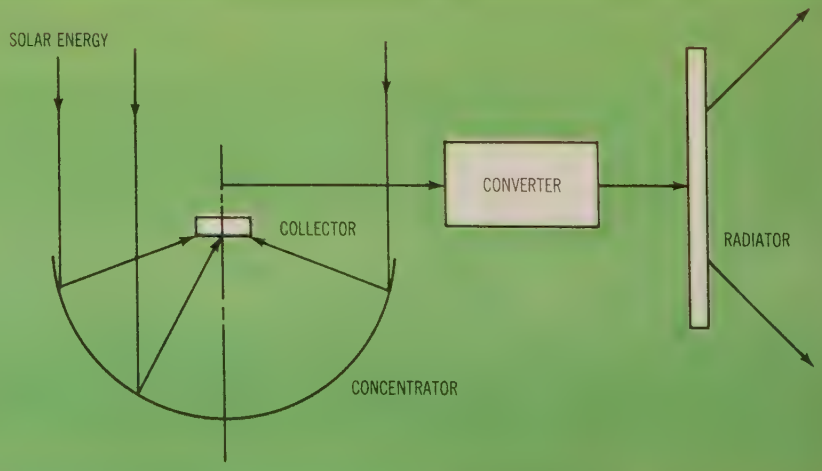


FIGURE 1: A typical solar-energy conversion system uses a mirror-type concentrator to focus solar radiation on a collector, which conveys the radiation to a passive converter like a thermoelectric generator or a dynamic turboelectric system. Waste heat is dumped by radiation into space.

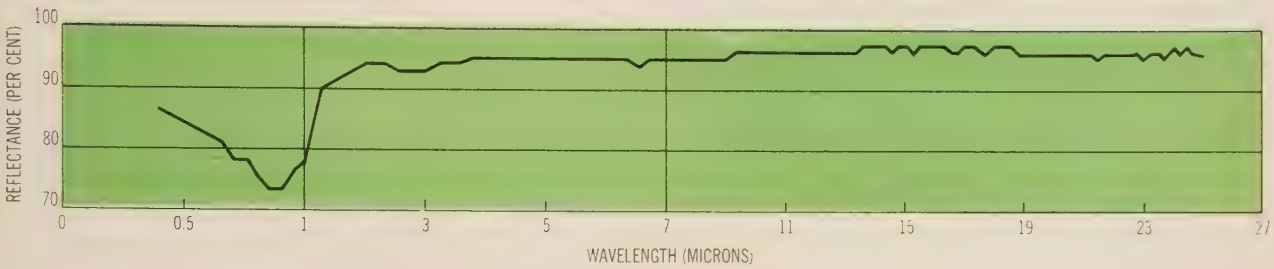


FIGURE 2: Spectral reflectance of the shiny side of household aluminum foil shows how radiation characteristics vary with wavelength. In the infrared, the reflectance is 95 per cent or better.

possible for the collector, while for the concentrator it should approach zero—for an opaque surface, the sum of reflectance and absorptance is zero, and maximum reflectance therefore requires minimum absorptance. The infrared emittance largely determines the energy losses by radiation from the collector as well as the effectiveness of the convertor in absorbing energy from the collector. The α/ϵ ratio provides an index of the relative amount of incident solar energy retained by a surface and is useful in predicting the equilibrium temperature of the surface.

For actual materials, α, ϵ, and their ratio must be determined empirically—we have no theory so far that takes into account the effects of surface conditions on radiation characteristics. The empirical determination can be made either calometrically or by calculation from reflectance values.

Data on spectral distribution needed

The second method is used more widely. It has the advantage of providing information on spectral distribution, which is essential for the adequate definition of characteristics (*Fig. 2*). Absorptance and emittance are determined from reflectance data by multiplicative integration of the spectral absorption curves and the black-body radiation curve for the appropriate temperature.

The calorimetric determinations of α, ϵ, and α/ϵ is based on the fundamental laws of thermodynamics. If a body absorbs solar energy and emits radiant energy characteristic of its temperature, its final equilibrium temperature is directly proportional to α/ϵ (*Fig. 3*). If the source of solar energy is removed, the temperature of the body will approach that of its surroundings at a rate determined by its emittance in accordance with the Stefan-Boltzmann Law.

Devices for the calorimetric measurement of radiation characteristics of materials require a solar energy source, which can be the sun, a heliostat sun image, or any one of a variety of commercially available solar simulators (*Fig. 4*). The incident radiant intensity is measured with a pyrheliometer. Convective losses are eliminated by a vacuum chamber and conductive losses minimized by the mechanical design. The chamber walls are cooled by liquid nitrogen, making radiation from the walls negligible, and the walls are platinum-blackened so that nearly all the energy emanating from the sample is absorbed by the walls. With such an apparatus, α, ϵ, and α/ϵ (*Fig. 5*) can be determined for any material in about 30 minutes with an accuracy of ± 5 per cent.

Research is underway to give us a better understanding of the physical parameters that effect the radiative behavior of materials, such as the effects of angle of incidence and surface roughness, and the relationship of α and ϵ to the optical constants of a material. We already know that the radiative response of materials is determined completely by a very thin layer of the exposed surface. A good electric conductor is optically opaque in the 0.2-25 micron range with a film thickness of just a few millionths of an inch; for a dielectric material, a few thousandths of an inch are required.

The effect of surface roughness and profile on radiative behavior can be explained satisfactorily by evaluation of the surface dimensions with respect to the wave-length of the incident and emitted radiation. While a surface with a micro-profile of one micron appears rough to incident visible solar radiation, it appears smooth to infrared energy. Surface roughness leads to multiple reflectances and increased absorption.

The idea of controlling radiation characteristics by manipulation of the surface profile seems promising. Emittance and absorptance control by depositing finely

Table I: Radiation Characteristics of a General Selection of Materials

	Surface Condition	α	ϵ	α/ϵ
Aluminum	polished & degreased	0.387	0.027	14.35
Gold plated on stainless steel	polished	0.301	0.028	10.77
Gold over titanium with resin undercoat	polished	0.300	0.033	9.10
Gold vacuum-deposited on Nil-A-148 slick, annealed aluminum foil	polished	0.282	0.034	8.29
Aluminum foil (dull side)	crinkled & smoothed	0.223	0.030	7.43
Beryllium	chemically & mechanically polished	0.444	0.063	7.04
Aluminum foil	cleaned with MEK & alcohol	0.218	0.032	6.81
Gold vacuum-deposited on silicone resin base	polished	0.344	0.051	6.75
Aluminum foil tape	as received	0.238	0.043	5.54
Aluminum foil (shiny side)	smooth	0.192	0.036	5.33
Inconel X foil	chemically polished	0.624	0.143	4.36
Aluminum	alchemized mill finish	0.218	0.051	4.28
Molybdenum slug	polished	0.480	0.122	3.94
Chrome-aluminized mylar film	as received	0.247	0.085	2.90
Aquadag (4 coats) on copper	clean	0.782	0.490	1.60
Carbon-black-pigment K silicate on Dow 17 on magnesium	clean	0.908	0.780	1.16
Rokide C (5 mils) on Rene 41		0.898	0.789	1.14
Dull black micobond (4 thick coats) on bare magnesium	clean	0.936	0.844	1.11
Aluminum oxide (mil thickness) flame-sprayed on aluminum	clean	0.422	0.765	0.55
Silica (5 coats) on magnesium	clean	0.349	0.825	0.42
Barium-titanate-pigmented silicone on Dow 17 on magnesium	clean	0.341	0.836	0.41
Zircon-pigmented K silicate on Dow 17 on magnesium	clean	0.195	0.830	0.23
Sodium silicate D & Wollastinite	clean	0.141	0.841	0.17

* Total hemispherical emittance at four degrees C.

divided particles on a surface has already proved feasible. A surface profile can be controlled by mechanical polishing and lapping, chem-milling, and electro-polishing. Surface treatment through the control of the size of pigment particles and of dispersion in film-forming paints or by the deposition of thin and transparent or translucent coatings is also feasible.

The spectrum of materials that have been tested for radiation characteristics is very broad, (*Table I*). Solar collectors require materials with high solar absorptance, low emittance at equilibrium temperature, and high thermal conductivity (*Table II*), while solar concentrators, boilers, and radiators require certain combinations of thermophysical properties. Cost, durability, and structural characteristics naturally must also be taken into consideration.

As surface materials for solar collectors and concentrators, nearly all metals have rather similar radiation characteristics. The choice among them therefore becomes a question of:

- formation of a stable oxide;
- limited oxidation;
- resistance to corrosion, atmospheric environmental effects; and tarnishing as a result of fingerprints;
- easy cleaning.

From every point of view, the material that again and again suggests itself is aluminum. Beryllium, once it becomes available as foil, perhaps will offer similarly great advantages.

For many applications, metallic foils offer the required radiative characteristics. In addition, they are relatively cheap and easily bonded to structural frame-

works. Aluminum foil is inexpensive, commercially available, and usually has an α/ϵ-ratio of about 8-10. Precious-metal foils are also available and practical. Titanium, tantalum, and beryllium foils are being produced in limited quantities, and foils of the refractory metals and of the new, high-nickel super-alloys are becoming available.

Foils can be used only if suitable high-temperature adhesives are available for bonding them. Research on such adhesives is making good progress—inorganic sodium silicate-aluminum acid phosphate adhesives have already proved their thermal stability up to 500 deg C.

As coatings for certain purposes—e.g., tanks used for low-temperature storage—materials with very low α/ϵ ratios are of interest. Many white paints have an α/ϵ-ratio of 0.3/0.9 or 0.32 and a relatively high solar reflectance of 70 per cent (achieved by the use of pigments with high indexes of refraction). Still lower α/ϵ-ratios, together with reflectances approaching 95 per cent, are shown by second-surface mirrors, for which opaque gold, silver, and aluminum coatings can be used.

To control the equilibrium temperature of solar cells, coatings have been developed that reflect all solar energy except that which is needed for the energy-conversion mechanism within the cells. Coatings are available that reflect nearly all the energy between nearly any two wavelengths while absorbing outside this range. As extremely thin films are used, the emittance of the coating does not depend on the reflected band.

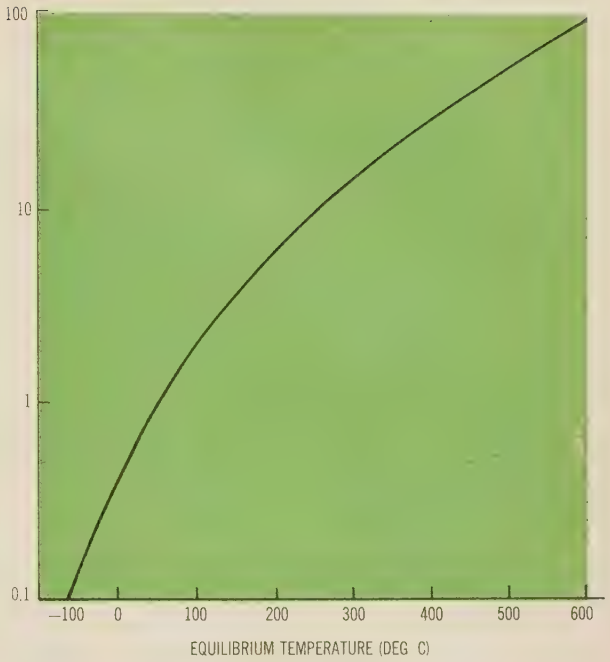


FIGURE 3: Typical plot of equilibrium temperature vs α/ϵ-ratio (assuming there is no convective loss and neglecting the ambient temperature).

Sapphire looks promising for mirrors

Fused silica and sapphire have been studied for solar collecting mirrors, with the latter showing particularly promising properties. One of the practical limitations of mirror-type solar concentrations is the temperature of the mirror. Sapphire is not only a highly transparent material and optically quite satisfactory, but it also has a thermal conductance nearly twenty times that of the ordinary transparent materials. It therefore can be used to minimize differential thermal expansion and problems of thermal cycling, which can make a mirror crack.

With synthetic sapphire, the cost would not be as prohibitive as might be expected. Mirrors of any appreciable size, however, would have to be made up of a large number of pieces held together in some fashion. We have found that the best materials for coating sapphire mirrors are aluminum and silver. Copper can then be electroformed on the coating and the composite structure soldered to a framework.

We have also done some work on metal mirrors of polished beryllium and aluminum. These mirrors cannot be ground to as fine a finish as conventional ones and therefore have less focusing power. They are satisfactory for many purposes, however, and do not suffer from any of the mechanical or thermal shortcomings of conventional transparent mirrors.

Metallized transparent plastic sheet materials have recently become commercially available. Aluminized mylar, which is available in thicknesses of 0.0005-0.01 in. and costs a few cents a square foot, is probably the best known of these.

The search for a material whose α/ϵ-ratio varies with temperature to maintain an approximately constant temperature even with varying incident flux has led to the study of the rare-earth elements. Gadolinium has radiation characteristics that look distinctly promising for solar collectors. Measurements of very highly polished gadolinium show a solar absorptance of 0.7-0.8 as

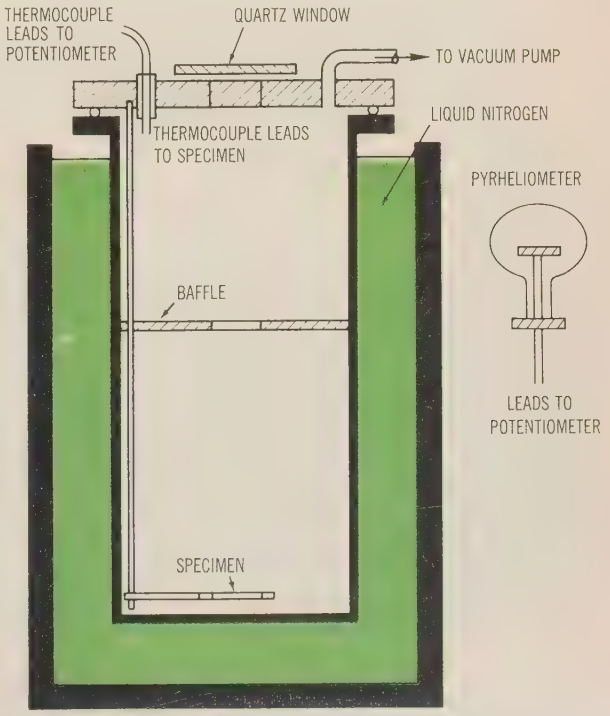
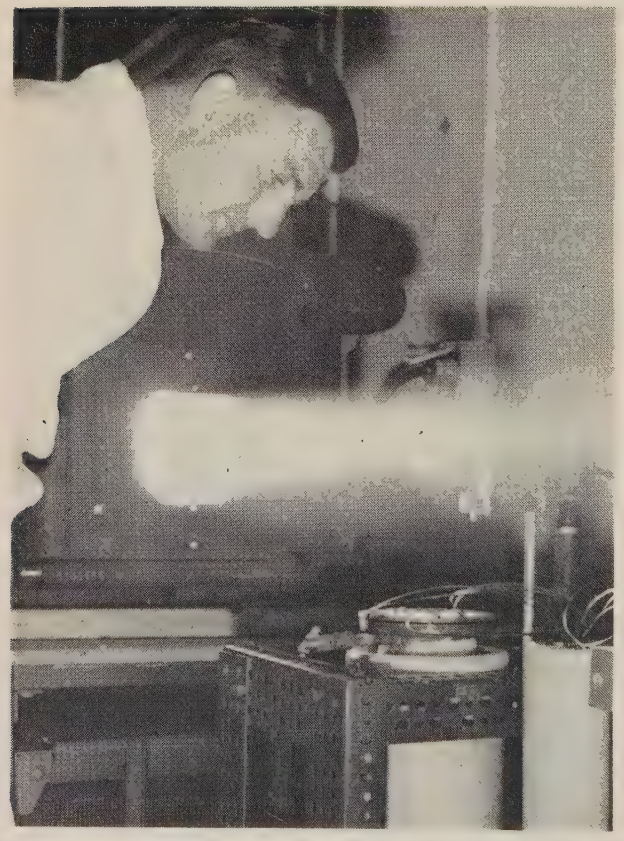


FIGURE 4: Apparatus used at Lockheed's Thermophysical Lab for the direct calorimetric determination of α/ϵ-ratios.

Table II: Radiation Characteristics of Materials for Solar Collectors*

		At 555 Deg R		At 1000 Deg R	
	α	ϵ	α/ϵ	ϵ	α/ϵ
Silicon-coated aluminum (10-micron polycrystalline film) on aluminum foil	0.522	0.12	4.35	0.12	4.35
Boron-doped silicon (approx. 1 mm) on nickel plate	0.938	0.316	2.97	0.497	1.89
Chromium plate (0.1 mil thick) on (0.5 mil) nickel plate on 321 stainless steel (exposed to JP-4 combustion products for 50 hr at 1100 deg F)	0.778	0.150	5.18	0.182	4.27
Tabor chemical treatment 110-30 on nickel-plated copper	0.853	0.049	17.4	0.078	10.9
Tabor chemical treatment 125-30 on nickel-plated copper	0.851	0.108	7.87	0.270	3.15
410 stainless steel (heated to 1300 deg F in air)	0.764	0.130	5.88	0.180	4.24
Titanium 75A (heated 300 hr at 850 deg F in air)	0.798	0.211	3.78	0.294	2.72
Titanium C-110 M (heated 100 hr at 800 deg F in air)	0.524	0.162	3.24	0.202	2.59
Titanium C-110 M (heated 300 hr at 850 deg F in air)	0.768	0.198	3.88	0.246	3.12
Titanium vapor coated on bright side of Reynolds Wrap aluminum foil (80-100 microns, heated 3 hr at 750 deg F in air)	0.746	0.138	5.40	0.212	3.52
Tabor chemical treatment of galvanized iron	0.885	0.122	7.25	0.264	3.36
Ebanol C on copper (treated 5 min. at 196 deg F in solution)	0.908	0.11	8.25		
Ebanol S on steel (treated 15 min. in solution)	0.848	0.10	8.49		
Ideal black body	1.000	1.00	1.00	1.000	1.00

* Under 442-btu/hr-sq ft irradiation from a 10,000-deg R Planckian radiator.



CALORIMETRIC determination of α/ϵ-ratio at Lockheed's lab. Solar energy is simulated by an arc beam reflected into a vacuum test chamber by a mirror.

against values of only about 0.3 for most highly polished metals. Preliminary calculations give gadolinium total hemispherical emittance at room temperature of 0.1.

In view of the very high solar absorptance of gadolinium, the efficiency of a solar collector coated with vacuum-deposited gadolinium would appear to be quite satisfactory. Gadolinium costs about $400 per pound or $0.25 per square foot at thickness of 0.01 mil—plus the cost of vacuum deposition, of course.

Stability and durability in the space environment are essential for the materials used for solar-energy control and conversion. Thin films and foils as well as highly polished surfaces are particularly susceptible to sputtering, evaporation, and micrometeorite erosion and pene-

Table III: Radiation Characteristics of Materials for Heat Rejection by Radiation*

		At 450 Deg R		At 1000 Deg R	
	α	ϵ	α/ϵ	ϵ	α/ϵ
6061-T6 aluminum (hard-anodized, 1 mil)	0.923	0.841	1.10	0.847	1.09
Inconel X (oxidized 4 hours at 1825 deg F in air, followed by 10 hours at 1300 deg F in air)	0.898	0.711	1.26	0.809	1.11
Armco black oxide on 301 stainless steel	0.891	0.746	1.19	0.756	1.18
Anodized titanium	0.515	0.866	0.59	0.835	0.62
Alumina flame-sprayed on 410 stainless steel (heated to 1300 deg F in air in 60 sec & held 30 sec)	0.276	0.801	0.34	0.790	0.35
Graphite (crushed carbon electrodes, 16 mils) on sodium silicate on polished aluminum	0.960	0.908	1.06	0.930	1.03
Glass (3 mils) on silicon	0.925	0.843	1.10	0.877	1.05
Titanox-RA (2 mils) on black paint	0.154	0.885	0.17	0.905	0.17
Flat black epoxy resin paint on aluminum	0.951	0.888	1.07	0.924	1.03
White epoxy resin paint on aluminum	0.248	0.882	0.28	0.912	0.27

* Under 100-btu/hr-sq ft irradiation from a 10,000-deg R Planckian radiator.

tration. Sputtering, or the removal of atoms from the surface of a material by the impact of atomic or subatomic particles, becomes significant in the presence of solar wind. For aluminum, for instance, the probability that a threshold energy level of about 506 ev, that an impacting solar wind particle will remove one or several atoms is high. A 300-A coating of aluminum would be destroyed in one month by a low-intensity solar wind. During a solar storm, it might be destroyed in a matter of several hours.

Pitting and erosion by micrometeorite impact could also seriously alter the radiative characteristics of concentrator radiators, and temperature-control surfaces. while the direct evaporation of metal could seriously affect the optical properties. If the thin oxide layer on a metal is lost and the metal is exposed, the emittance generally drops sharply and the value of temperature equilibrium changes.

For paint-type materials, the question of ultra-violet stability arises. Among several inorganic paints consisting of sodium silicate vehicle and various refractory oxide pigments that we have developed, the most effective seems to be one that uses zirconium oxide pigment, which has proved relatively stable in the course of a full year's continuous exposure to the equivalent of solar radiation in space. The α/ϵ-ratio for this paint is 0.25. Particularly in the case of spectrally flat absorbers used on boilers, this stability should be carefully tested under repetitive thermal cycling.

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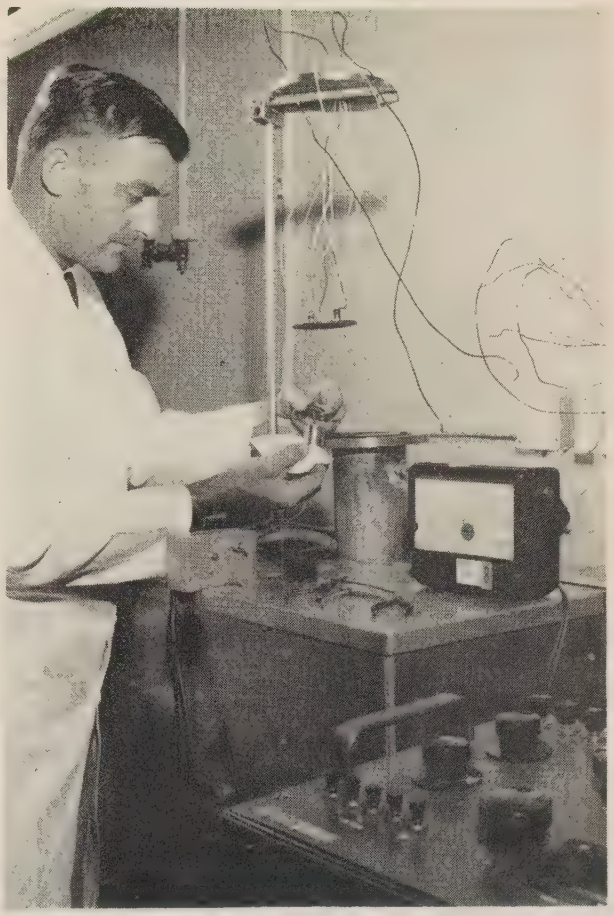

SPECIMEN is loaded into a total-hemispherical-emissivity calorimeter. It can be brought to any temperature between 200 and about 1200 deg K by a filament heater.

Experimental stress analysis
a must for solid rocket cases

EXPERIMENTAL TESTING has never been more important than in the development of rocket motor cases. Not only do the design requirements specify the lowest weight compatible with reliability, but there is also the need to predict, with reasonable certainty, the conditions under which these thin-wall cases will fail. Beyond that, development time and cost must be kept to a minimum. Only by anticipating the factors that cause theoretically unpredictable failure can optimum designs be achieved without wasting time and money.

Essentially, a rocket motor case is a pressure vessel. A large amount of data on the design of conventional pressure vessels is available, but it is not directly applicable to cases with high strength-weight ratios. To achieve these ratios, the case material invariably must be heat-treated to a high strength level. At this level, material tends to behave unpredictably under the stress characteristic of case loads. This condition leads to notch sensitivity, which causes most case failures, to which, of course, other factors—like minute cracks, inclusions, and occlusions acting as stress raisers, abrupt changes in configuration (surface and contour deviations), and material variables—also contribute. All these problems become worse as cases become bigger.

Theoretical stress analysis provides some answers, but most of these problems must be solved experimentally. The quickest and cheapest approach is to run a hydrostatic test program on a limited number of sub- and full-scale cases in conjunction with an experimental stress analysis based on strain gage results.

At Solar, test programs of this kind have been run on cases up to 5½ ft in diameter. The strain data obtained during the last two phases (sub- and full-scale testing and evaluation) of a recent program covering large cases show the backlog of experience that can be built up and then applied to new programs. This program was designed to provide strain measurements for regions in which discontinuity stresses prevail and the stress distributions can be found theoretically with reasonable accuracy.

The lightweight case we analyzed was 20 ft long and over 60 in. in diameter. (*Fig. 1*). Stresses were reproduced adequately with the sub-scale chosen as half-scale. The great advantage of sub-scale testing is that design size effects are minimized.

Accurate gage installation and data reduction proved very important. In regions of known principal stress directions we used two-gage rosettes; otherwise three-gage rosettes were used. For areas in which the surface contours precluded the use of commercially available gages, our experimental stress engineers had to make

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IN BRIEF

An intensive search has been underway for the most accurate method of stress analysis for solid rocket motor cases. At their very high required strength levels, the case materials tend to behave unpredictably, ruling out the use of conventional pressure-vessel design theory. Instead, experimental stress analysis is usually needed.

This report reviews an extensive program of this kind, set up to determine the actual stresses at weld joints. It analyzes the problems of the test arrangement, including gaging and error correction, and shows how the test results can be used to gain a better understanding of stress distributions, particularly in areas for which theoretical stress analysis is difficult. The test procedure for welded cases largely applies to fiber-wound cases, too, whose fibers must be oriented in the principal stress directions if optimum strength-weight ratios are to be achieved.

by R. D. Evans and G. K. Schmitz, Project Engineer &
Senior Research Engineer, Solar Aircraft Co.*

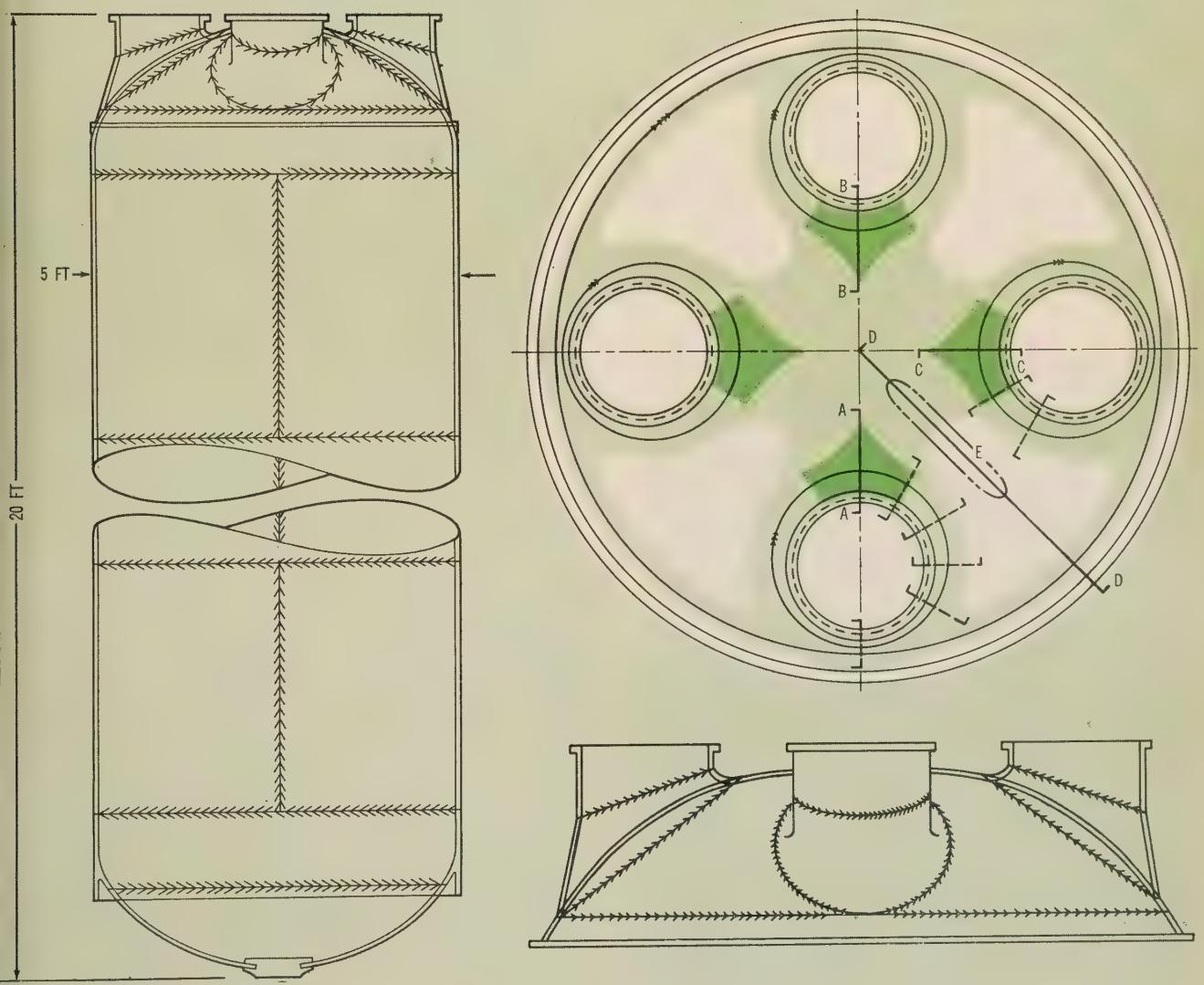

FIGURE 1: Large, lightweight case assembly (left) studied in an experimental stress analysis program at Solar had forward and aft closures of the same 1.4:1 ellipsoid contour. Its components were all drawn or rolled from sheet and then welded together, except for the brazed joint of the igniter boss to the forward head. The aft closure and the case cylinder were joined by a conventional flange and high-strength bolt arrangement. Similar analyses have been run on slightly larger cases. Right: Welded aft closure shows the sections experimentally analyzed by Solar and the areas of high discontinuity stresses (light shading) and of maximum discontinuity stresses (dark shading). On the basis of these test results, Solar undertook a successful development program that led to a pressure-forming operation designed to keep down bending stresses.

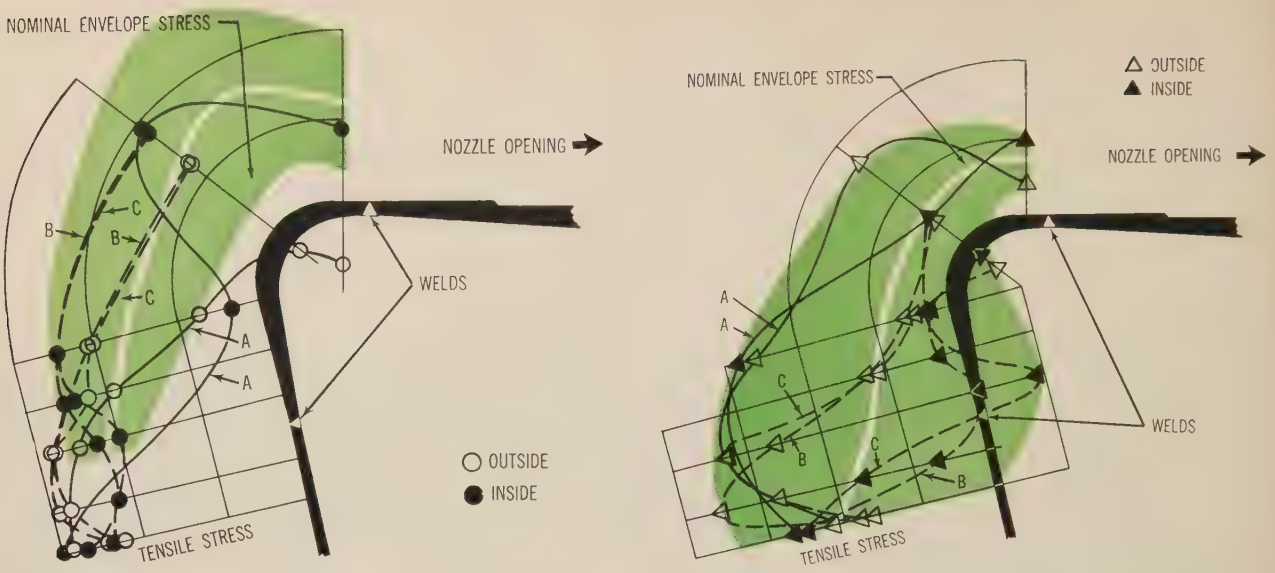

FIGURE 2: Hoop stresses (left) and meridional stresses (right) measured at two gage points in sub-scale tests of three of the sections shown in Figure 1 and stress envelope and nominal, or mean, stress. Steep stress gradients and a pronounced stress reversal are shown by the meridional measurements.

EXTERNAL strain-gage installation on a typical closure. The area shown in this picture was covered by 312 gages.

their own rosettes. Both internal and external rosettes were installed to obtain surface strain data from which stresses could be calculated.

A total of 1300 strain gages was used in the program. The closure tests alone accounted for over 50 per cent of this total, which shows how difficult it would be to analyze such a component theoretically. A typical closure gage installation consisted of 312 gages.

Which kind of rosette—rectangular, delta, etc.—is used makes little difference. More important is the choice of gage type. Flat grid wire, flat grid foil, and wrap-around helical grid gages are in common use. After a preliminary evaluation, we decided on the flat grid foil type, because of the consistent results it gave and because it was easy to install.

"Sandwich" rosettes may be useful

When strain gradients are rather high within a short distance, as near a weld, it may be highly advantageous to use rosettes made of a sandwich of these gages. In this way, stresses at a specific point can be found. However, different corrections are needed for the bottom and top gages in such an arrangement.

Because the readings from the gages are influenced by strain in the transverse direction as well as along the axis of the gage, they do not give the exact actual strain. Another reading error may be produced by the relationship between the strain field in which the gages are used and the field in which the gages were calibrated. For this relationship, transverse field coefficients can be calculated for both actual and calibrated conditions.

From these coefficients and a transverse-sensitivity coefficient, a correction factor can be calculated. This factor may be greater or less than unity, depending on the type of gage and the strain field in which it is used. In most cases, it is difficult to obtain, since most strain-gage makers don't specify transverse-sensitivity coefficients or the conditions of their gage calibration.

Other factors that affect the accuracy of the reduced train data are:

- deviation of the gage factor from the value listed by the manufacturer, which is found statistically;
- variations between external and internal gage locations at a given gage point and their orientation with respect to maximum and minimum stress axes;
- the effect of biaxial fields on transverse gage sensitivity (on which few quantitative data are available);
- the accuracy of the recording instrumentation (specifically of the strain-gage calibration and the print-out);
- the accuracy of strain-stress nomographs, which depends on the values assumed for the modulus of elasticity and Poisson's ratio;
- the accuracy of stress values determined from strain curves that are still linear above the material's proportional limit;
- variations of stress rationalization above yield.

Error ranges are hard to find

It is difficult to find the exact magnitude of error ranges. However, analysis of data from our program as well as from lab tests on smaller pressure vessels showed an average error range of ±3 per cent and a range of ±5 per cent under unfavorable conditions.

The closure data from our program typify the many stress problems met in the case assembly as a whole (*Fig. 1 & 2*). When the nominal stresses are set up from statistical data in the form shown in *Figure 2*, they can be assumed to represent the stress normally present under the same load conditions for similar cases—providing there are no discontinuity stresses. However, there always are discontinuity stresses (in varying degrees). They are the result of bending loads at the points in question, and their magnitude therefore is shown by the nominal stress designation.

We evaluated our basic design primarily on the basis of hydrostatic burst tests of half-scale cases. During these tests, extensive strain-gaging was used to find out whether the basic configuration had been correctly chosen. Two case areas were strain-gaged—a membrane area and an area characteristic of the geometry discontinuities.

Membrane areas have constant thicknesses and contours; geometry-discontinuity areas include welds, nozzle and igniter boss transition sections, and the like. For the former, theoretical analysis is readily applied; for the latter, it is strictly rational, time-consuming, and at times inaccurate. Only by strain-gaging these areas can the designer find out whether the nominal wall thicknesses of the case material have been chosen correctly—whether the stresses produced by the design loads are

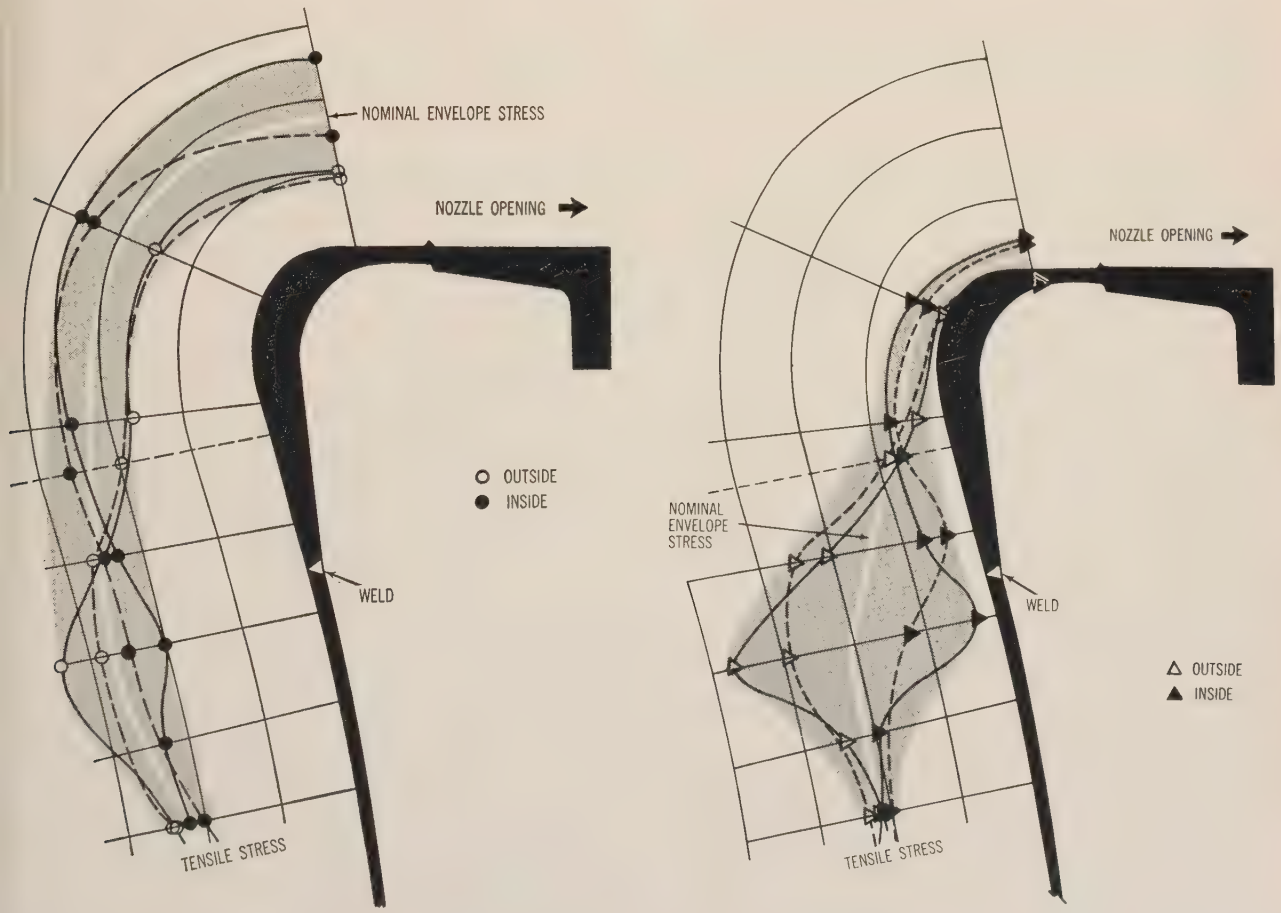

FIGURE 3: Hoop stresses (left) and meridional stresses (right) measured at two gage points on section A of Figure 1 in full-scale tests. The meridional measurements show a considerable reduction in stress gradients and bending stresses, which resulted from improvements prompted by the results of the sub-scale tests.

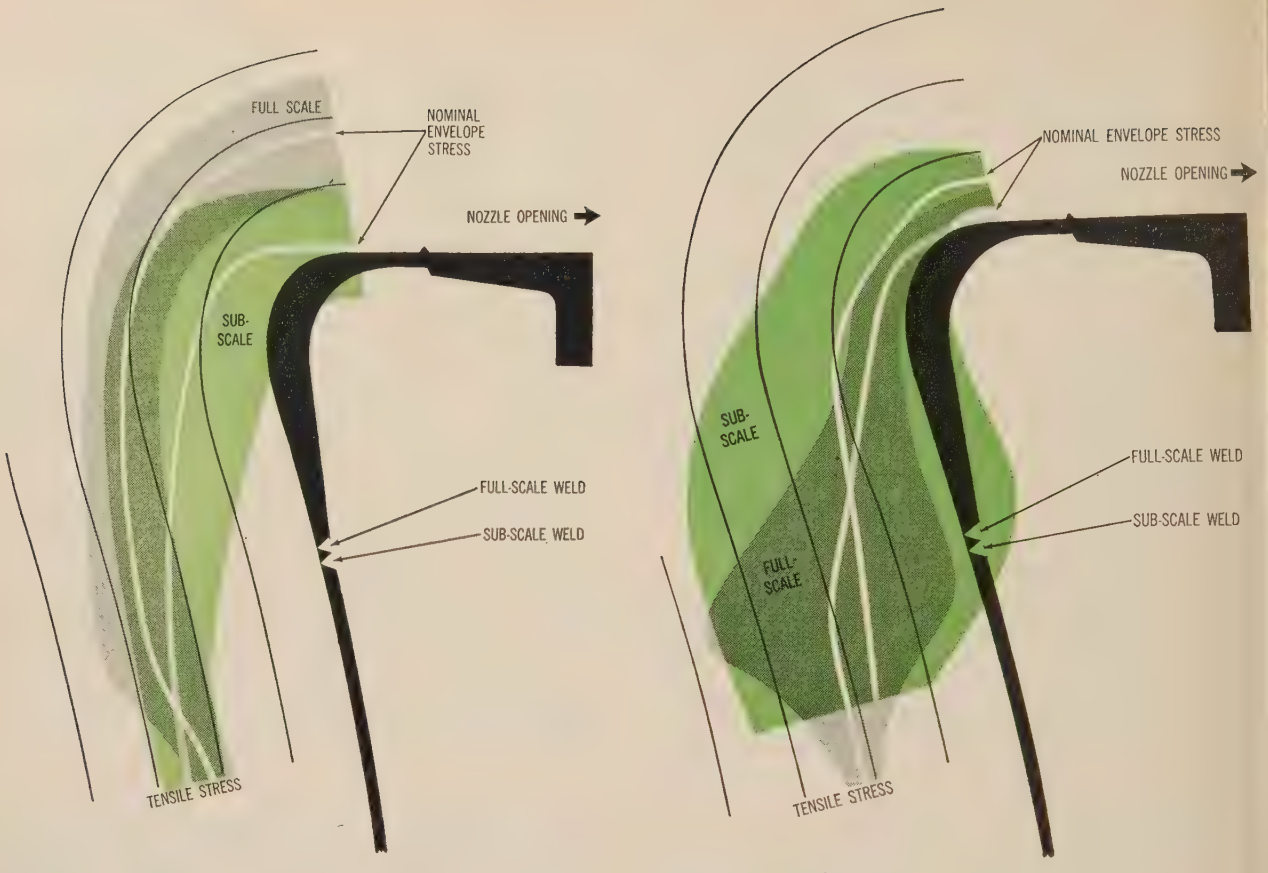

FIGURE 4: Effects of design modifications (made after sub-scale tests) on the hoop stress (left) and meridional stress (right) of a high-stress area of the case shown in Figure 1.

near, but don't exceed, the design stresses.

We found that, when cases fail prematurely, the stress results from the gage points can be extrapolated to higher case pressures to determine the expected stress levels at those pressures. When such extrapolation produces values in excess of the material's uniaxial yield strength, though, the results are no longer valid, since the stress-strain relationship becomes non-linear above this point. Strain data therefore can be used only on a rational basis above this point.

On the basis of the half-scale test results, we modified our full-scale design. The hoop and meridional stress data for the area around the nozzle bosses of two half-scale closures showed large variations between inside and outside surfaces (*Fig. 2*). At nearly all gage points, these variations pointed to the presence of rather high bending stresses in both stress directions. Such bending stresses are caused primarily by excessive weld mismatch and by contour and thickness variations. The sub-scale results also showed—as a result of manufacturing inconsistencies—differences between the two test closures in the magnitude of the surface stress at corresponding nozzle points.

Figure 3 shows the effectiveness of the design and manufacturing changes we made as a result of the half-scale tests. There was a marked reduction in bending stresses, the result both of less abrupt transition between boss and membrane and of improved weld assembly methods.

Figure 4, which compares half- and full-scale stress envelopes and nominal stresses, shows the overall improvement in stress distribution. The full-scale closure stresses are appreciably higher, indicating a more efficient closure design and an increase in the strength-weight ratio. This increase was achieved by noting the nominal stress level of the half-scale closure and scaling the full-scale membrane thicknesses to a higher stress level (without exceeding the design requirements).

Generally, manufacturing variables are introduced in the production of either the raw materials or of the case itself. They must be watched with extreme care because small geometry discontinuities can lead to high surface stresses and so cause catastrophic failures at less than the design load. Whenever in our development program the stresses varied significantly from test to test or deviated from the theoretical values, analysis invariably led to a modification of the manufacturing process or a tightening of manufacturing tolerances.

Weld redesign was often needed

Probably our worst manufacturing problem was posed by stress concentrations at weld joints. The steep meridional stress gradients of *Figure 2* are typical, together with a pronounced stress reversal, of severe contour discontinuities (in this case, a weld mismatch). *Figure 3* shows considerable reduction in these stress gradients as a result of weld redesign; *Figure 4* shows a 20 per cent reduction of the meridional bending stresses near the weld location as a result of improved welding methods and weld assembly.

Whether a case design is acceptable depends on the relationship of the maximum stresses that are produced to the allowable for whatever the direction of the max-

imum stresses may be. The magnitudes of these stresses depend on the amount of nominal stress plus and minus the discontinuity stresses. If rather high discontinuity stresses are present in what is normally a direction of minimum stress, this direction can become the principal direction of maximum stress. This happened in the immediate vicinity of the weld of *Figure 3*, where the maximum stress was produced meridionally on the outside surface, normally the direction of minimum stress. (The majority of the maximum-stress values in this area, though, occurred in the hoop direction.)

The variables that produced these variations and deviations included:

- *Surface or Contour Irregularities*—Ovality, bow, sheet thickness variation, flat spots, weld mismatch, weld bead contour, 2nd contour distortion caused by heat treatment or welding;
- *Material Variables*—inclusions in raw materials, grain-size variations in the end product, decarburization, variation of physical properties as a result of heat treatment, and physical properties of welds.

The example of a relatively undisturbed section of our closure makes clear the advantages to be gained from an experimental stress analysis program. A comparison of the calculated stress distributions in this section (based on the average material thickness) for a full-scale closure of uniform wall thickness and of the corresponding strain-gage data shows that the two sets of stresses agree reasonably well (*Fig. 5*). At some points, though, the nominal stress is about 10-15 per cent below the predicted values—the result of actual thickness in excess of the theoretical one.

The discontinuity stresses in region E were produced by stress fields around the nozzle bosses. These non-uniform fields to some extent, of course, were caused by design discontinuities, but chiefly they were due to weld effects.

The remaining stress distribution in the section shown in *Figure 5* reveals less pronounced discontinuity characteristics—a sign that the major contour distortion was near region E. Despite a considerable difference in the rigidities of the flange connections, there was little variation between the results of separate tests of the closures (mounted on rigid plates) and of tests of the same closures in case assemblies. This proved that the flange effect was restricted to the immediate flange area and to the adjacent flange-to-membrane joint.

After review of our closure test results in terms of the severity of discontinuity stresses (*Fig. 1*), we decided that a cheap and reliable method of reducing bending stresses would be a great help. As a result, we developed a new pressure-forming operation that removes contour discontinuities. In the case of a typical full-scale head configuration with a centrally located, welded igniter boss, this operation reduced bending stresses by 60 per cent, but this value does not represent the limit of what can be accomplished. Generally, our assumption that pressure-forming would improve an entire head or closure assembly has by now been proved correct by many applications involving a variety of case configurations.

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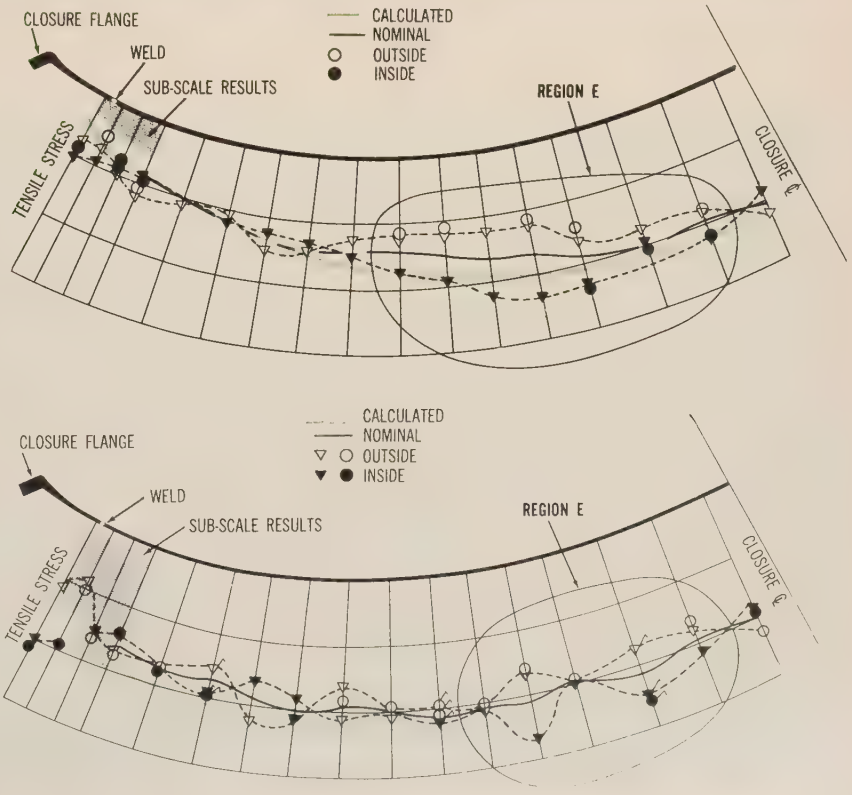

FIGURE 5: Theoretical hoop stresses (top) and meridional stresses (bottom) for section D of Figure 1 and values measured in full-scale component tests (triangles) and assembly tests (circles). Hooks indicate discontinuity stresses. Sub-scale tests were run only on the flange weld region, which was of primary interest to the Solar designers. They resulted in low stress values and led to a modification of the full-scale design.

STATE OF THE ART

by B. M. Corley,
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Solid-propellant gas generators

THE BEST solid propellants for gas generators use rubber-like or polymeric materials as the fuel-binder and ammonium nitrate (AN) as the oxidizer. They can be extruded, cast, or compression-molded into the desired grain configuration.

The propellant charge of a gas generator, which may vary from ½ to 28 lb, generally takes one of three basic forms:

- tubular perforations, with all surfaces burning;
- perforated cylindrical grain, with only the inner surface burning;
- solid cylindrical grain, with only one end burning.

The solid propellant starter for the large turbopump systems of the Saturn H-1 and Atlas MA-3 liquid-propellant rockets uses multiple tubular perforations (*Fig. 1*). It produces 5600 gas hp for one second and has a reproducible ignition delay of less than 30 milliseconds. Its high output requires a relatively high flame temperature of 2450 deg F and burning rate of 0.2 ips at 1000 psia.

The installation of this low-cost starter has cut propulsion system weight by about 120 lb. In 1500 starts, it has proved 99.8 per cent reliable. The coefficient of variation, based on time and pressure parameters, for the more than 7000 starters that have been built is about three per cent.

Perforated grains burning only on the inside typically

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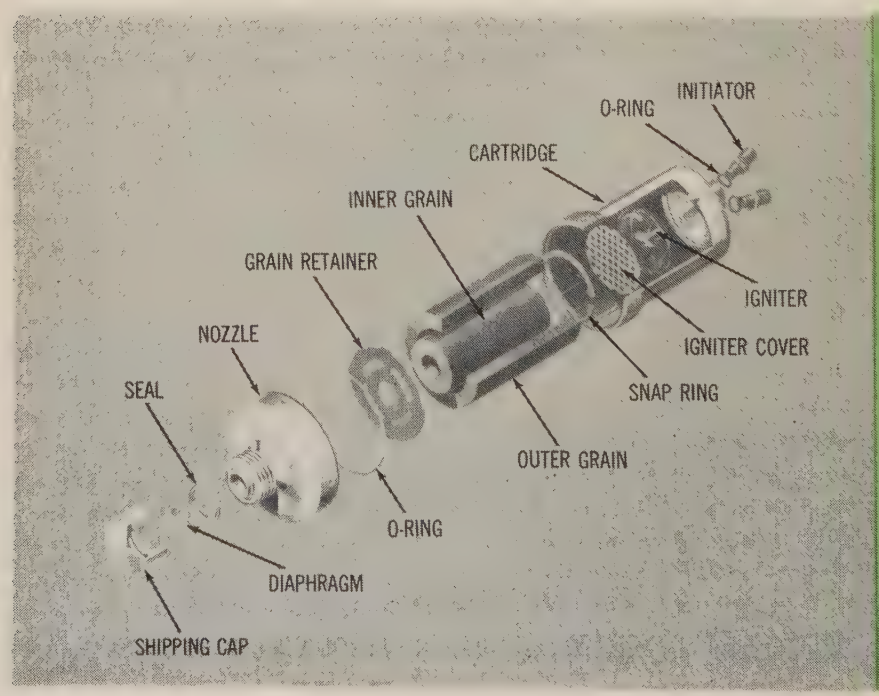


FIGURE 1: Solid-propellant starter for turbopump systems of the H-1 and MA-3 liquid rockets.

IN BRIEF

Recent advances in solid propellent gas-generator design include reduced flame temperatures, lower burning rates, and improved environmental stability. Generally, flame temperatures are reduced or varied by adjusting the rate of oxidizer to fuel binder or by the addition of organic coolants. To achieve temperatures of less than 1600 deg F, however, methods like passing the exhaust gas over a coolant bed of organic coolant must be used. Burning rates can be reduced by the specially drilled oxidizers, or again with the help of organic coolants. These coolants, however, also reduce the available specific energy. For repeated temperature cycling over a range from —70 to 170 deg F, changes in the volume of the crystal structure of ammonium nitrate oxidizer have been a problem. By substituting phase-stabilized AN for the pure material in propellants, this "grain growth" is sharply reduced.

are used in low-cost jet engine starter-generators. A generator of this type may produce 450 gas hp for 19 seconds. Its propellant flame temperature then would be less than 2100 deg F (not enough to damage any starter component) and its burning rate 0.12 ips at 1000 psia. The range of reliable and reproducible ignition without excessive ignitor shock would extend from —75 to 170 deg F.

Rubber-based restrictors are very effective in this temperature range and actually extend it to 200 deg F. The restrictor provides the required pressure-time relationship and reduces heat transfer to the case wall, eliminating costly extra insulation. Its decomposition products will not plug orifices or turbine passages.

Examples of "cigarette-burning" generators whose propellant grains form solid cylinders burning at one end only are the Mk 2 and 3 APUS on the Tartar and Terrier missiles (*Fig. 2*). They burn the same propellant as the jet-engine starter we have already described, but their ignition system is unique. They have a boost stage—about one second in duration—to overcome the inertia of turbines and other rotating hardware. An initiator provides primary ignition, and the boost pressure is built up quickly by means of a disk of fast-burning propellant and four holes drilled in the end of the main-stage charge. The outer surface of the grain is tapered to provide regressive main-stage pressure as compensation for APU-component warm-up during flight.

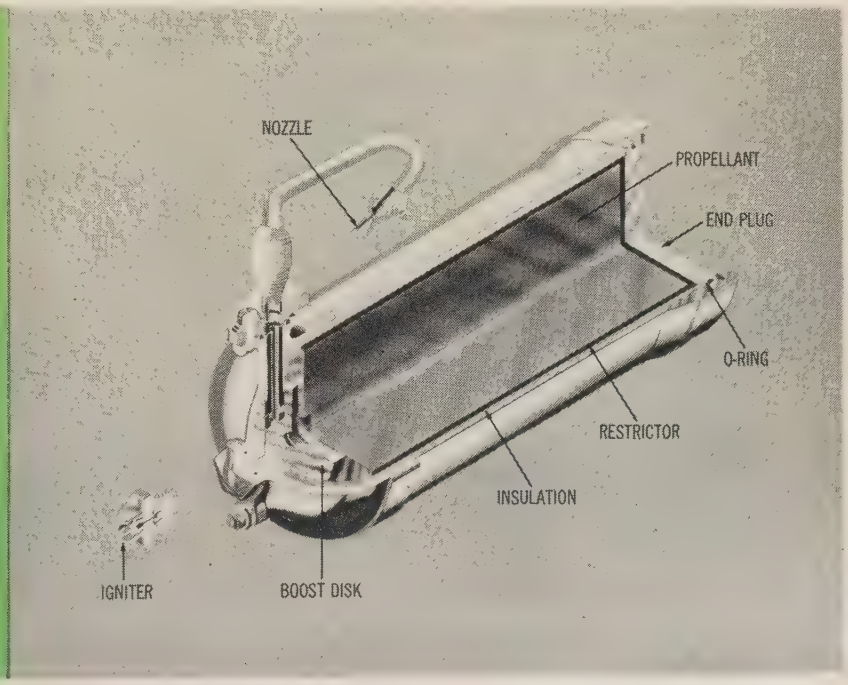


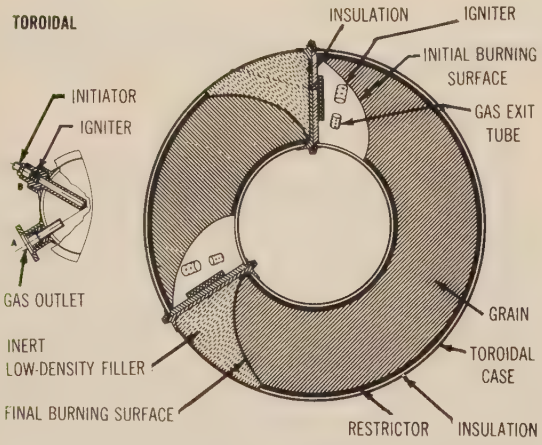
FIGURE 2: Solid-propellant generators for Tartar and Terrier APUs both have this design but differ in size.

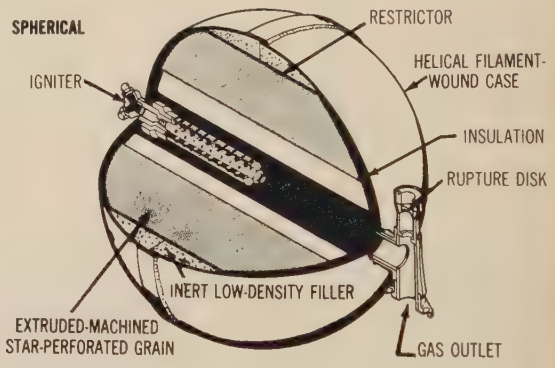
Advanced Designs

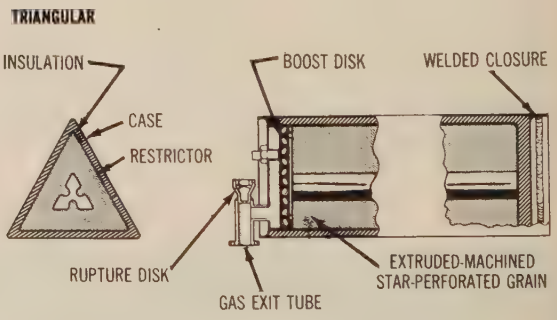
Solid-propellant gas generators designed to meet new requirements and make better use of available space have been taking odd shapes. The spherical generators, for instance, achieve extra structural strength by their shell design. As a result they have exceptionally high mass-weight ratio, and potentially high mass-flow.

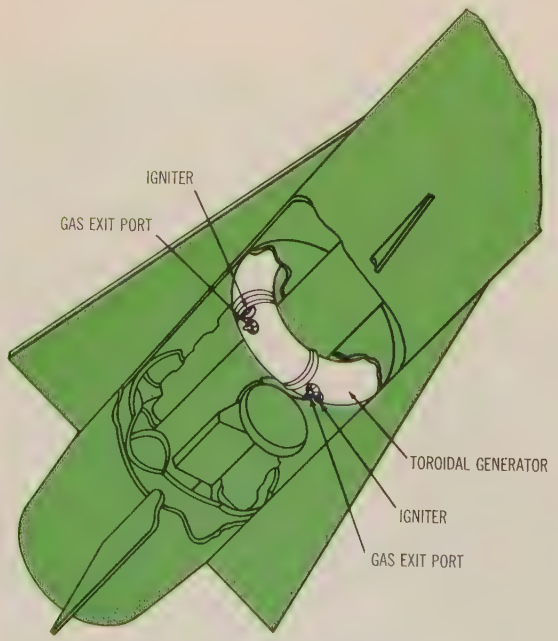
Toroidal generators can be inserted where cylindrical units will not fit. They provide long durations and high gas horsepower while taking up minimum space and may be adapted to thrust vector control as well as to hydraulic and electric power supplies. Currently they produce 40 gas horsepower for 120 seconds.

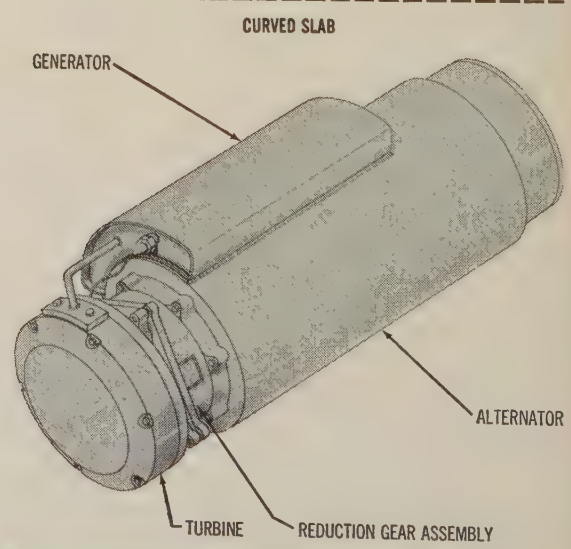
The triangular generator has not yet been applied in practice. It has the disadvantage of a poor pressure-vessel configuration and requires extra support from the vehicle structure.

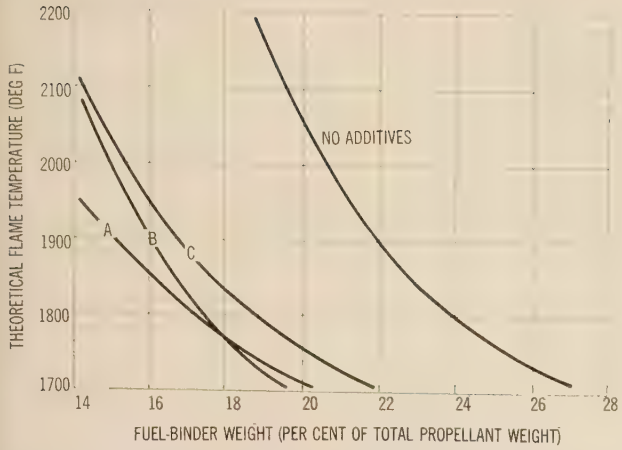












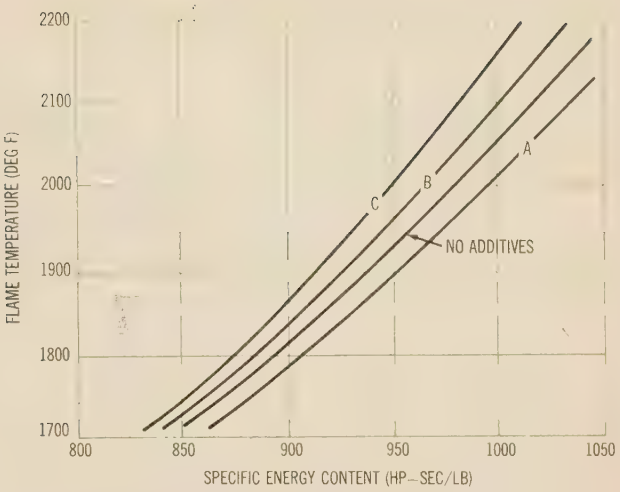


FIGURE 3: Effects of the substitution of three coolant additives for 10 per cent of the oxidizer on the theoretical flame temperature and specific energy content of composite solid propellants.

The Tartar and Terrier generators have proved highly reliable in many firings. Their average coefficient of chamber-pressure variation has been about three per cent.

Synthetic rubber as fuel and binder

The most common gas-generator propellants today use a synthetic rubber as a combination fuel and binder and AN as the oxidizer. Though these propellants perform excellently, the search is on for wider ranges of flame temperature and burning rate as well as for better ballistic characteristics and environmental stability.

Experimental propellants already have produced a clean-flame temperature of only 1700 deg F. Basically, flame temperatures can be manipulated either by varying the ratio of fuel-binder to oxidizer or by the inclusion of organic coolants like dicyandiamide and ammonium oxalate (*Fig. 3*). These coolants, however, must be chosen with an eye to their effects on ballistic characteristics and on the cleanliness of the combustion products.

Energy is also lost

Reductions in the flame temperature of composite propellants are accompanied by reductions in the total energy that can be stored in a given volume (*Fig. 3*). There is an energy loss of 16 per cent, for example, when the flame temperature is reduced from 2100 to 1700 deg F. Even when the flame is held constant at 2100 deg F, the substitution of ammonium oxalate for 10 per cent of the oxidizer reduces the specific energy by about 3.5 per cent.

Coolant A of *Figure 3*, though, produces a small increase in specific energy, because of the more favorable molecular weight of the exhaust gas. A formulation using coolant A produces 980 hp-sec/lb at 1970 deg F, while one using ammonium oxalate would have to reach 2100 deg F to produce the same specific energy.

Both theoretical calculations and experimental results indicate that it may be impractical to reduce the flame temperatures of a composite propellant much below 1600 deg F. Also, equilibriums other than the water-gas reaction become important below 1900 deg F, and methane has been detected in the combustion products at these temperatures.*

Combustion products are diluted

The problem is that certain applications—like tank pressurization in liquid-propellant systems—require flame temperatures below 1600 deg F. A practical solution of this poser is to use a separate coolant bed that lowers the temperature of the combustion products as the hot exhaust gases pass over ammonium oxalate or some other organic coolant (*Fig. 4*). Specifically, the exhaust temperature is reduced by diluting the combustion products with the coolant decomposition products.

Stable burning rates have been brought down to as little as 0.03 ips at 1000 psia and flame temperatures of 2000-2100 deg F by the use of specially drilled oxidizers and the inclusion of organic coolants. As we have noted, though, organic coolants reduce the specific energy. This is important because usually the required total power is the controlling factor rather than the burning time (which is extended by a low burning rate).

The sensitivity of the burning rate to pressure and the temperature coefficient of equilibrium pressure determine the permissible range of operating temperatures for a gas-generator propellant. Normally the propellants using AN as the oxidizer have pressure exponents of about 0.5 and temperature sensitivities of 0.12-0.14 per deg F.

Recent experimental studies of liquid polymer as a fuel for castable propellants have shown pressure exponents as low as 0.32. While no practical means have yet been found for reducing the pressure exponent to zero, experiments have proved that this can be done in a high-energy composite propellant with ammonium perchlorate as the oxidizer. There is hope that the same may be true for AN formulations.

To achieve the desired pressure-time characteristics, it is usually necessary to restrict burning to certain surfaces of each propellant grain. For simple cigarette-type

* F. R. Gassner, Jr., "Non-Equilibrium Reactions in Solid Propellant Gas Generators;" *ARS J.*, Nov. '60.

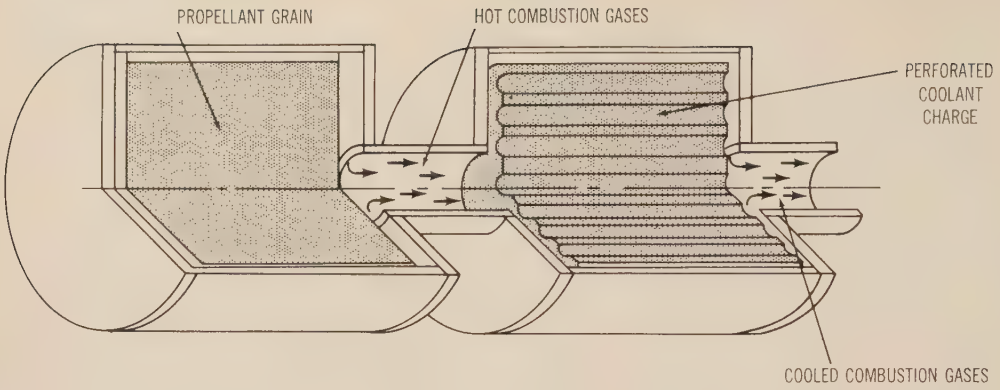


FIGURE 4: Coolant bed for the reduction of the temperature of propellant combustion gases.

burning, the outer surface and one end of the cylinders are coated with a restrictor. Because the binder is a synthetic rubber, these surfaces can be "restricted" by bonding a sheet of pure synthetic rubber to the grain under heat and pressure.

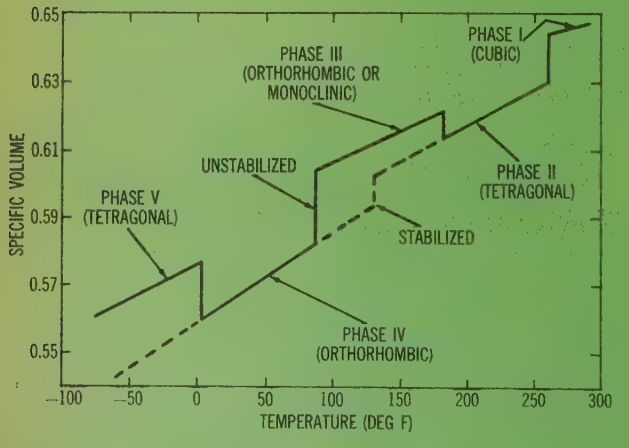
Liquid restrictors, which are poured or cast around the grain or used to pot the grain into cases, recently have provided cheaper and quicker restriction methods. A further improvement of this technique has led to a thixatropic system that can be painted or rolled onto, and cured to, the grain without further flow.

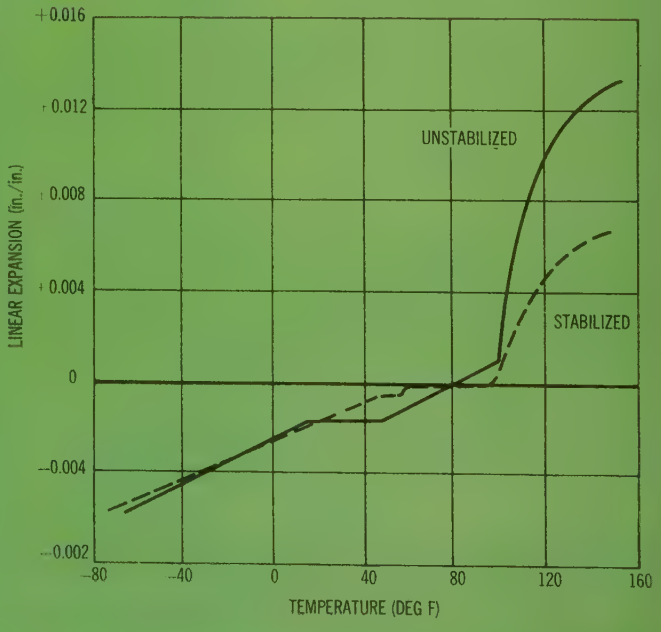
Extrudable propellants of AN and synthetic rubber can be stored for long periods at any temperature between —75 and 170 deg F without significant changes in their ballistic or mechanical properties. The cured binder's properties compensate for changes in oxidizer volume (caused in turn by changes in the crystal structure).

After repeated cycling between —75 and 170 deg F, however, the binder can no longer adjust completely to the volume change of pure AN, and some permanent "grain growth" may result.

Volume changes due to grain growth are sharply reduced by the use of phase-stabilized AN instead of the pure form, which exists in three crystalline phases (III, IV, and V) over the temperature range of interest. The substitution of phase-stabilized AN has reduced grain growth after 20 cycles between —65 and 170 deg F from 16 to about four per cent by volume and sharply lowered expansion above room temperature (*Fig. 5*).

FIGURE 5: Effects of phase stabilization on the volume stability and linear expansion of ammonium nitrate oxidizer.





y G. L. Neidhardt and F. T. Sasaki, Group Leader
Associate Research Engineer, Mechanics Research Div.,
merican Machine & Foundry Co.*

Inertial test table

is stable to 10^{-6} g

THE AIR FORCE'S primary requirement for a platform for the testing and calibration of ICBM inertial-guidance components was freedom from acceleration due to external causes greater than 10^{-6} g, over the range of 0.2-200 cps. No known site in this country has this kind of natural seismic stability, and the normal operating conditions of a test facility obviously would make the ambient vibration only worse.

We have therefore designed a "stable table" to meet the USAF requirement, which has already been tested in model form. Six such tables will be installed at a site with natural accelerations of 10^{-5} g (peaking at about nine cps).

Six degrees of freedom must be taken into account in the design of a stable platform—three linear and three rotational. Our stable table is suspended on a pendulum rod from a compound spring-toggle mechanism (*Fig. 1*). The spring-toggle functions as a soft spring limiting the transmission of vertical vibrations. The pendulum rod intercepts vibrations in both horizontal directions and

* Mechanics Research Div., American Machine & Foundry Co., 7501 N. Natchez Ave., Niles 48, Ill.

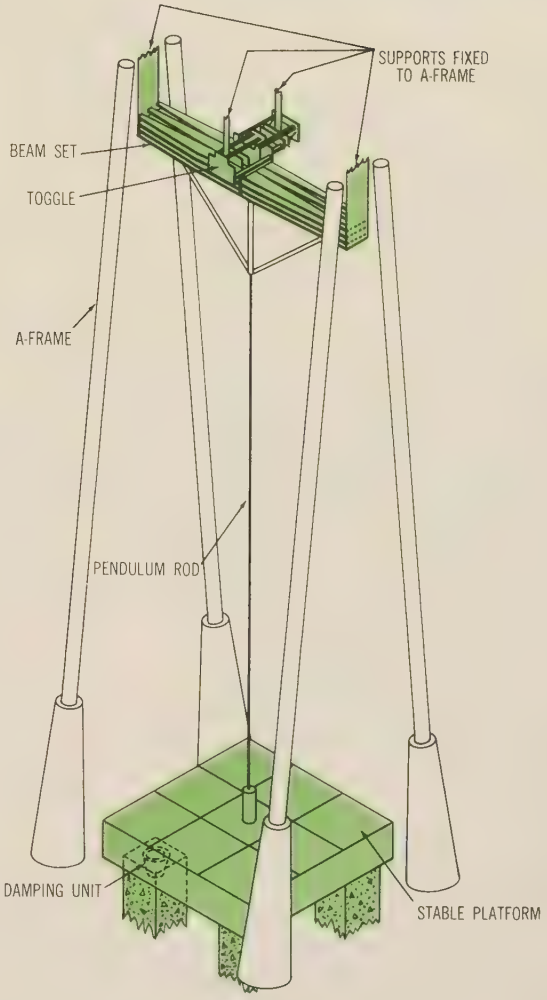
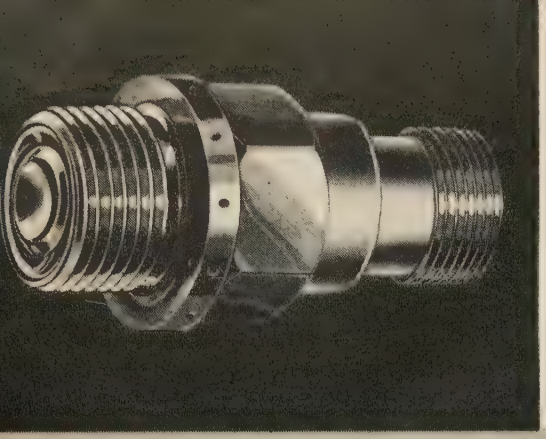


FIGURE 1: AMF stable table with beam spring and toggle, pendulum-rod suspension, and damping units.

IN BRIEF

A test platform for the calibration of inertial-guidance components has been designed to experience accelerations no greater than 10^{-6} g at frequencies from 0.2 to 200 cps. Its suspension system consisting of a toggle mechanism and a beam spring operating in parallel, intercepts vertical vibrations. The table is suspended from the beam-toggle compound by a pendulum rod that absorbs rotational vibrations. A damping system prevents the persistence of any vibrations that may occur.

The negative spring rate of the toggle and the positive rate of the beam spring add to give a very small positive rate for the compound. An adjustment screw in the toggle mechanism provides control of the spring rate to very narrow limits.



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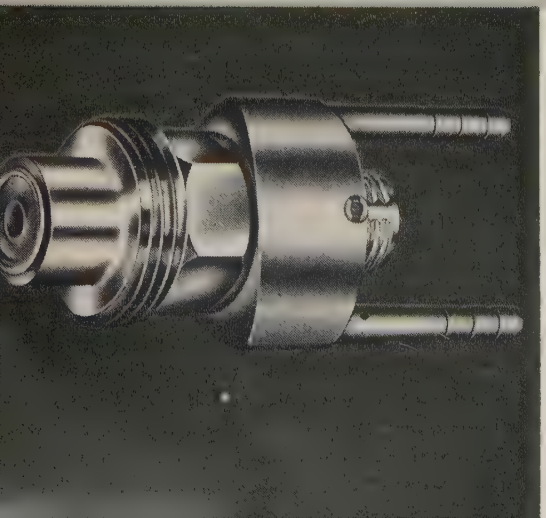

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ɔtational vibrations about the vertical axis. The ends of e pendulum rod act as flexure hinges, and the rotation ɔout both horizontal axes is intercepted by flexure of ıe upper end of the rod.

We chose the spring-toggle combination because, to ɔvide the required isolation, the design natural fre- ıency of the platform has to be 0.19 cps or less. The equency of vibration for a mass suspended from a ɔring is:

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}\ cps,$$

here k is the spring constant (in lb/ft) and m is the ıspended mass (in slugs). As the static deflection and ıe suspended mass are:

$$\delta_{st} = W/k, \quad m = W/g,$$

ith W being the weight in pounds, we get:

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{\delta_{st}}}.$$

endulum rod had to be 22.6 ft long

For the desired maximum design frequency of 0.19 ɔs, the static deflection therefore is 22.6 ft. For a gross ıble weight, including test equipment and ballast, of 0,000 lb. a spring rate of about 74 lb/in. gives the equired natural frequency. The required length (l) of ıe pendulum rod we calculated as 22.6 ft on the asis of:

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{l}}.$$

As a coil or beam spring to provide 22.6 ft of static eflection would have been unmanageably big, we had ɔ find a spring system with a decidedly non-linear load- eflection relationship. A toggle has this non-linearity *Fig. 2*). The frequency of small vibrations is governed y the local spring rate, which is the slope of the load- eflection curve at the position of static equilibrium. he negative slope indicates a region of instability— nder a given applied load, the toggle seeks one of the able regions indicated by a positive slope.

A toggle could be designed to support the table just ıort of the peak load bordering the region of instability, ut it is better to compound the toggle with a linear ɔring so that their loads add. If the spring rate of the near spring exceeds the maximum negative spring rate f the toggle, the resulting spring-toggle compound has soft region without instability.

hree toggle members joined by hinges

The toggle consists of three members joined by hinges. he combined length of the two shorter members, or ms, is slightly greater than that of the third, or base, ɔ that the arms are in compression and the base is in nsion when the toggle hinges are nearly aligned (*Fig.*). The toggle is designed to a negative spring rate of 1,253 lb/in. when the hinges are in alignment. The ıear spring is in the form of a set of nine simply sup- ɔrted beams, has a set spring rate of 11,327 lb/in., ving the spring-toggle compound the desired rate of 4 lb/in.

To achieve these high spring rates, the toggle design lls for a cross-section of 5.3 sq in. for each of the ree members, while each of the beams of the linear ring is 124 in. long, two inches thick, five inches wide the midpoint, and tapers to two inches at each end. ɔth the toggle and the beams will be made of beryllium

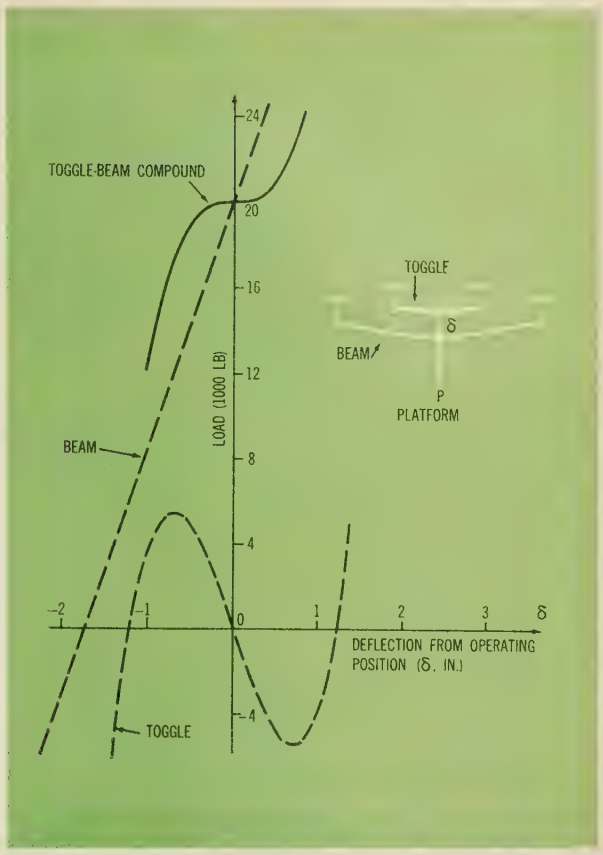


FIGURE 2: Load vs deflection for toggle and beam springs and a toggle-beam compound.

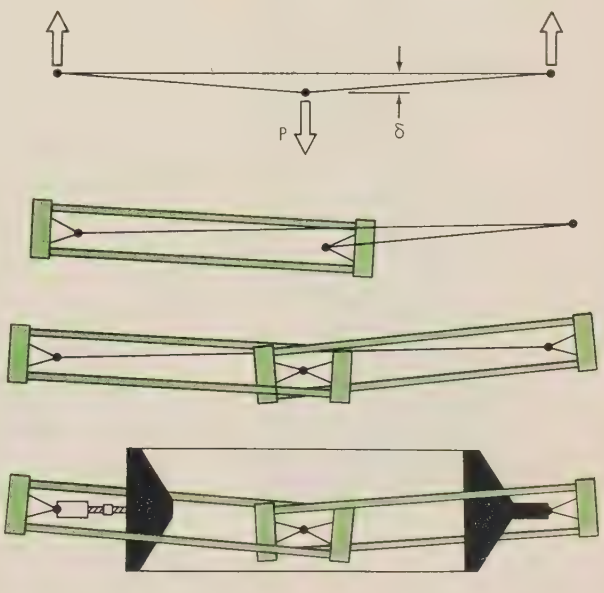
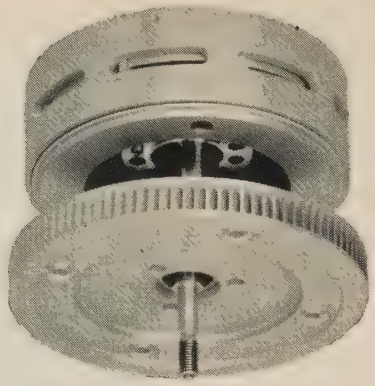


FIGURE 3: Basic toggle mechanism with arms in compression and base in tension when the hinges are nearly aligned (top); one and both arms extended beyond their hinge points, from where their flexure straps, which are in tension, return to the hinge points (center); and toggle with a divided base to let the center hinge move freely through the point at which all three hinges lie in a straight line (bottom).



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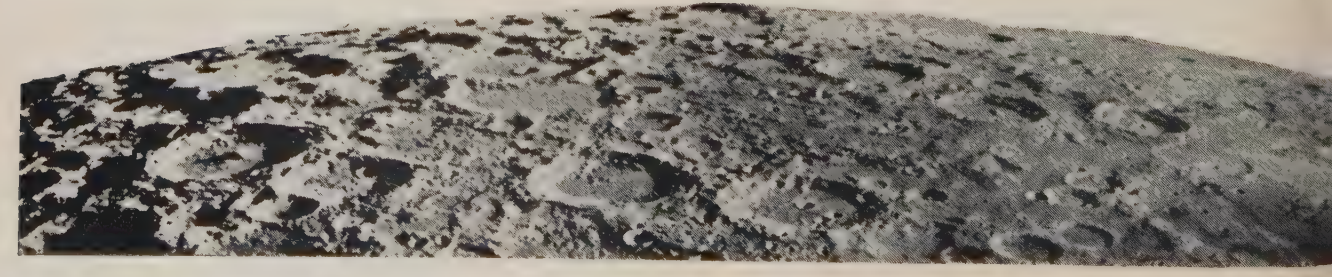

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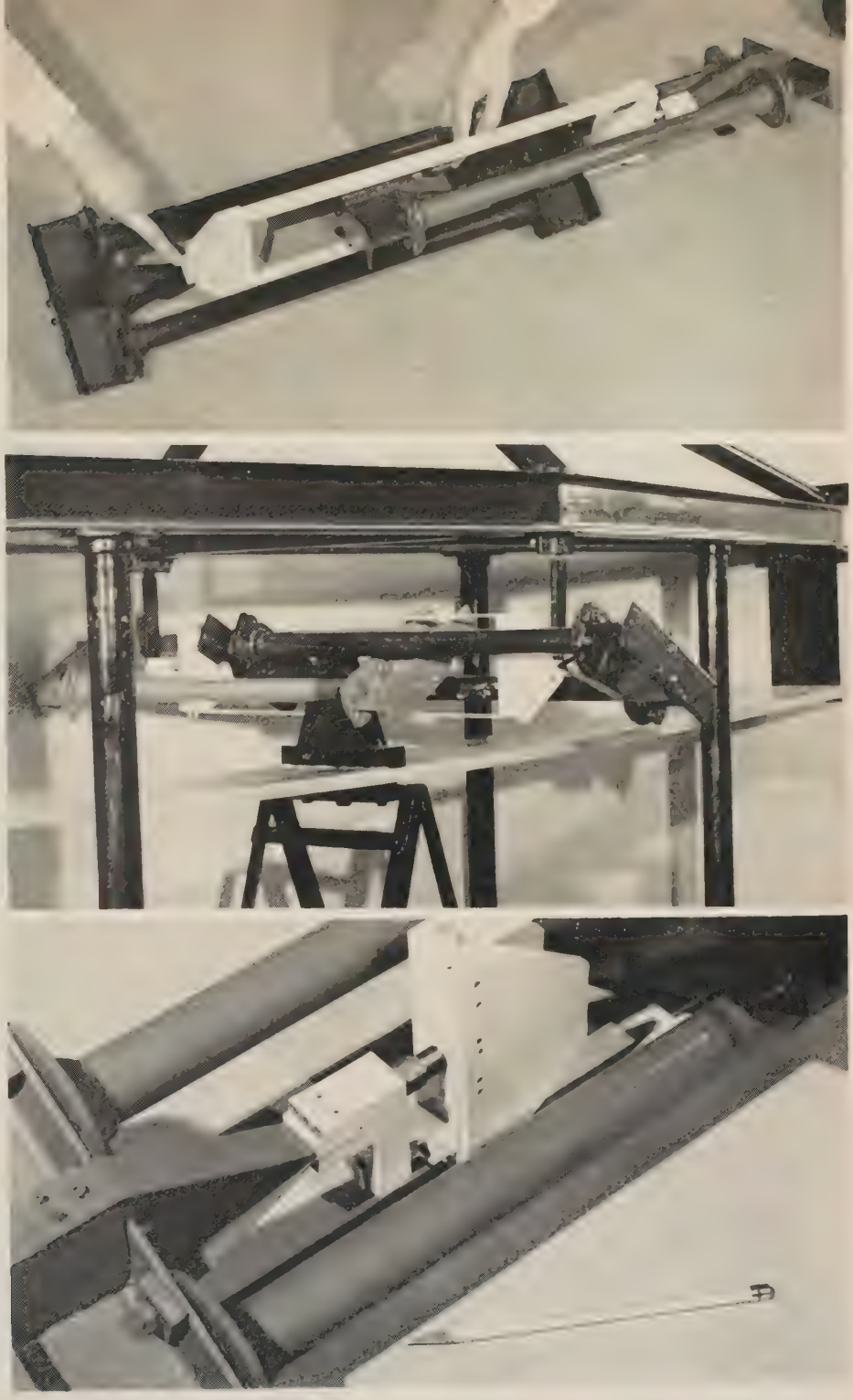

FIGURE 4: Model of toggle mechanism (top), showing (l. to r.) the flexure hinge joining the base and one of the arms, the hinge between the arms, which also serves as the attachment point for the beam spring, and the fine-adjustment screw. Center: Model of the beam-toggle compound attached to the main support structure. A dummy table is suspended from the A-frames below the spring. (The pendulum rod and damping were omitted in the model.) Bottom: Fine-adjustment screw and flexure-hinge arrangement of the model.

copper to avoid any possibility of damaging creep. The design stress is limited to about 20,000 psi, considerably less than the mechanism's yield point of 90,000 psi.

Relative arm lengths are critical

Each toggle arm measures 15 in. between the hinge points; the base measures 29.92 in. between these points. The relative length of the toggle members must be maintained with extreme accuracy. A change in the length of one member of 0.00052 in. would cause the spring rate of the spring-toggle compound to change by 100 per cent of the desired value. A fine-adjustment screw is therefore provided in the toggle base. The screw resembles a turn-buckle, but has right-hand threads at both ends, with 36 threads per inch at one and and 40 at the other. A 6¾ deg turn of this screw will change the length of the toggle members by only 0.000052 in., changing the spring rate by only 10 per cent of the target value.

Flexure straps must be used for the toggle hinges to eliminate any possibility of bearing friction. As these straps would buckle under compression, the toggle members must be arranged so that the straps are in tension. This is done by making each of the compression members of a pair of parallel rods that extend past the hinge points and are joined by rigid end blocks (*Fig. 3*). The base is also split, so that the center hinge passes through the point at which all three hinges lie in a straight line.

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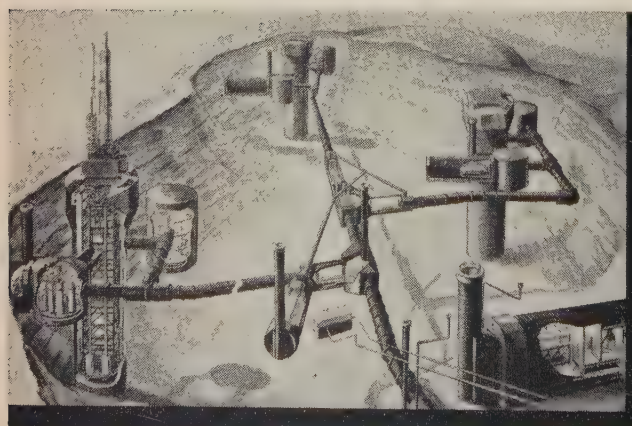

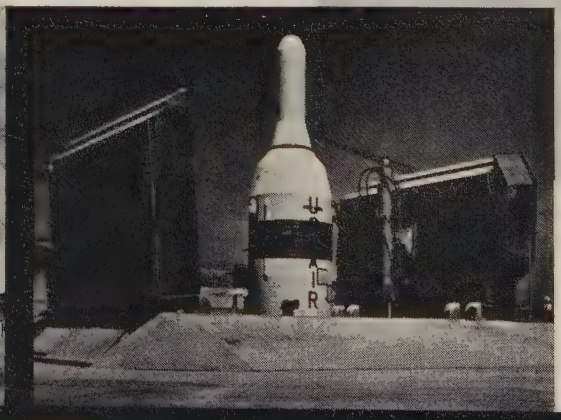

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To show that our design is feasible and that the spring rate can be controlled by the toggle-adjustment screw to make the natural frequency predictably small in comparison with that for the beam spring alone, we tested a steel model of the spring-toggle compound (*Fig. 4*). A single beam spring was used and a dummy table. The fine-adjustment screw had 20 threads per inch at one end and 24 at the other.

Load-deflection readings from this model clearly show that the spring rate of the compound can be controlled by the toggle-adjustment screw (*Fig. 5*). We also checked the natural frequencies and found them to agree with the observed spring rates.

Damped system's response has two peaks

Vibrations in all six directions are damped by fluid damping units underneath the platform. The damping coefficients for the 20,000-lb table were selected to provide optimum response curves. The response of the damped system has two peaks, one at the resonant frequency and one at the frequency of maximum input. The optimum coefficient, which makes the response the same at the two peaks, was found to be 93 lb-sec/ft for vertical motion and 285 lb-sec/ft for horizontal motion. The damping units operate on the principle that, when two parallel surfaces with a fluid between them approach each other with a given velocity, the fluid must escape with a much higher velocity, offering a mechanical advantage in the viscous effect of the fluid.

Since the motions of the platform are of different magnitudes for the six directions, any damping unit must be able to provide the right amount of damping in each direction. The damping unit must also be as small as possible to keep the effect of the buoyant force of the liquid negligible. To get the required damping with simple viscous shear of parallel surfaces at a reasonable separation we would have had to use rather large shear areas, and the dampers would have been too buoyant.

Concentric cones with a central angle of 36 deg, on the other hand, provide the fluid-squeezing surfaces without excessive buoyancy. A viscous silicone oil will be used as the damping fluid, with a network of grooves in one of the cones to help dissipate the kinetic energy. While three damping units are enough provide the same order of damping for all three rotational modes as is provided for translation, four units will be used in the design as more convenient with a square platform.

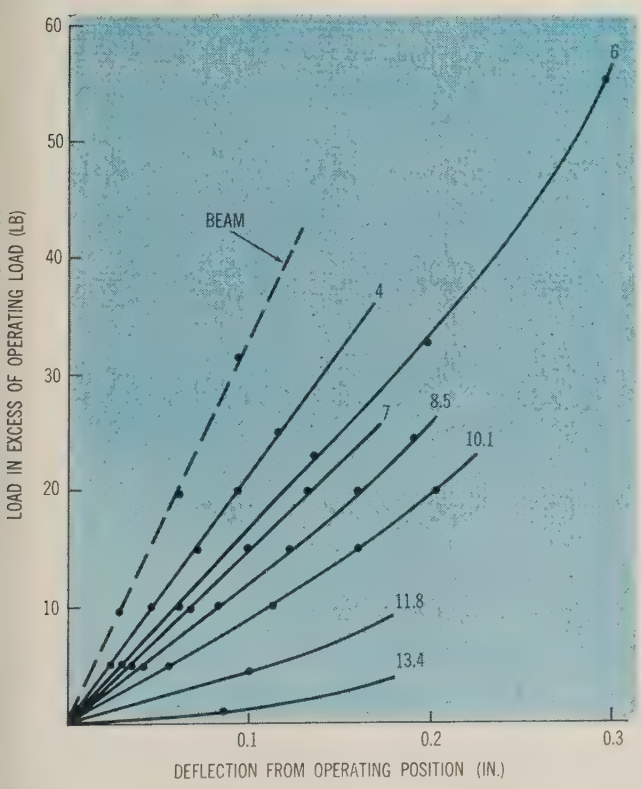
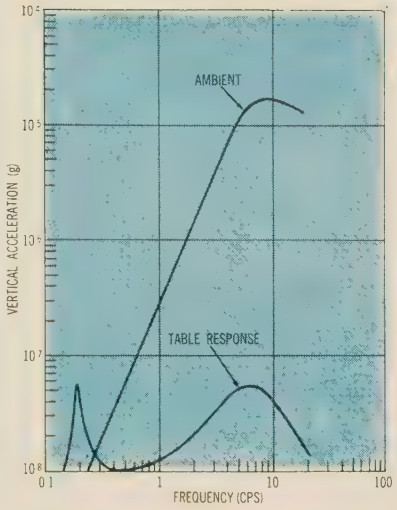


FIGURE 5: Load vs deflection of the model beam-toggle compound for several numbers of turns of the fine-adjustment screw.



OPTIMUM response curve of AMF's 20,000-lb stable table (excluding secondary effects).

Fixed and movable ballast can be used

The seven-foot-square platform has provision for both fixed and movable ballast, the first to adjust the total weight and the other for balance. The flexure hinge of the suspension rod will keep the platform level with respect to the local gravity vector, but initial leveling will be necessary, since the loads cannot be arranged with perfect symmetry. The movable ballast consists of lead counterweights sliding on a pair of horizontal, orthogonal rods.

A pair of extremely accurate surveyor's levels are mounted orthogonally on a triangular leveling plate attached to the platform. These will be used for the final leveling after the platform has been roughly leveled with a less sensitive, circular-type level (also attached to the platform).

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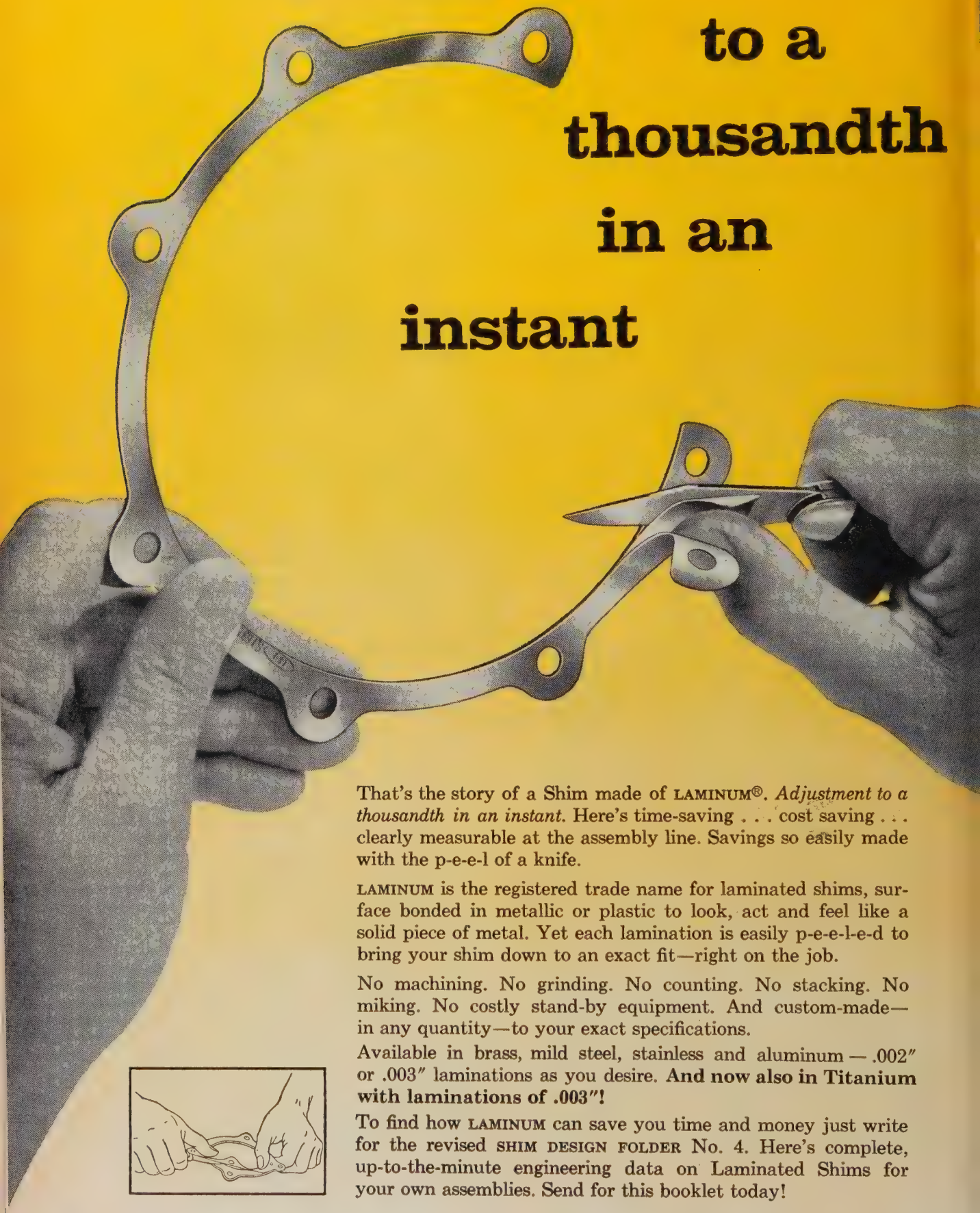

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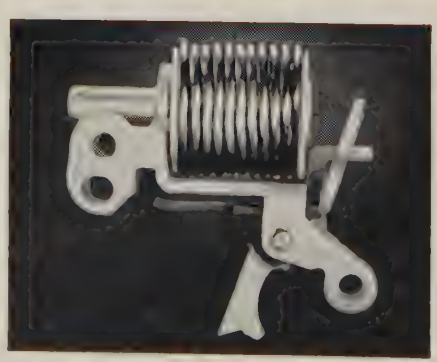

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Production Engineering

Materials

Structures

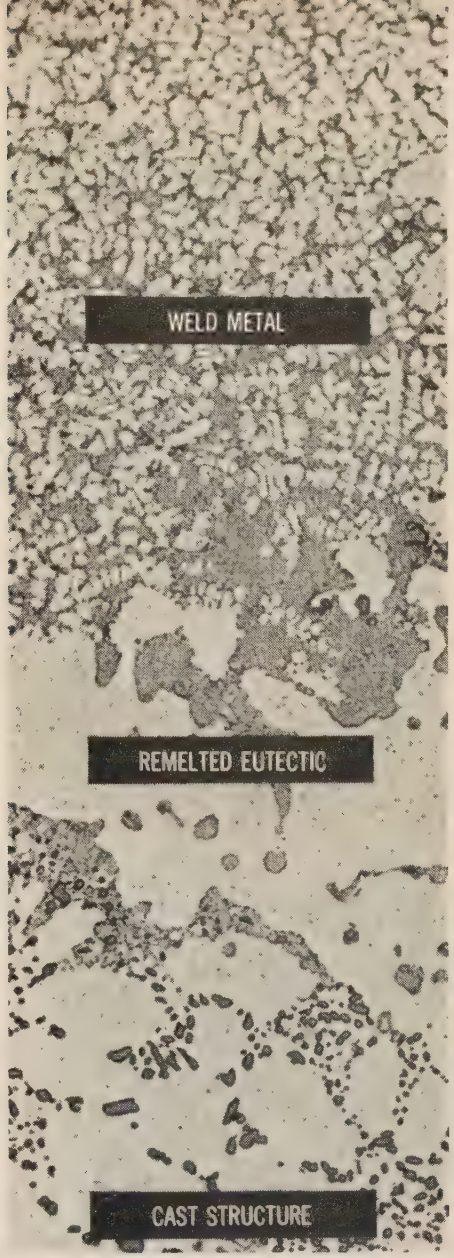
by John G. Fisher, Senior Research Engineer,
Rocketdyne Div., North American Aviation, Inc.*

New aluminum alloy solves weld heat-treat problem

THE PROBLEM of welding heat-treatable aluminum alloys without sacrificing strength has been with us for a long time. Many efforts have been made to weld the copper-aluminum hardening alloys like 2014 and 2024. The goal in these cases has been to reduce eutectic melting in the heat-affected zones on the sides of the weld, but this effect lowers the mechanical properties to well below the strength of the unwelded base metal. Moreover, these attempts have generally been unsuccessful, except with thin sheet.

The truly weldable and heat-treatable alloys are based on the aluminum-magnesium-silicon system—6061, 6066, 356, etc. Unfortunately, they have a tendency toward hot shortness near the melting point. The most common of these alloys is 6061. It contains 0.6 per cent silicon and one per cent magnesium. Because of its hot shortness,

* Rocketdyne Div., North American Aviation, Inc., 6633 Canoga Ave., Canoga Park, California.



FUSION REPAIR in as cast Tens 50, the casting (right) has the normal cast structure with good sodium modification. The middle zone also is part of the casting, but the eutectic has melted and chilled again rapidly, producing a micrograin size refinement. The region at the far left is Tens 50, with exceedingly fine micrograin size.

IN BRIEF

Despite all the talk about exotic alloys, aluminum is still a major material in just about all advanced aerospace systems. Thus it's still of great importance for designers to have efficient weldable and heat-treatable aluminum alloy systems. A major problem for them has been the lack of a filler material for use with the weldable and heat-treatable aluminum-magnesium-silicon alloy systems. NAA now has developed Tens 50 casting alloy, an aluminum-magnesium-silicon alloy modified by sodium and 0.1 per cent beryllium. This report covers comparison tests of assemblies welded or modified with Tens 50 and with other weld filler materials, the applications Tens 50 and the design of assemblies using this alloy, as well as welding and heat-treat methods.

Ideas you can use from

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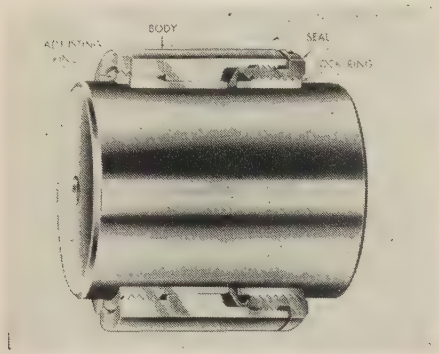

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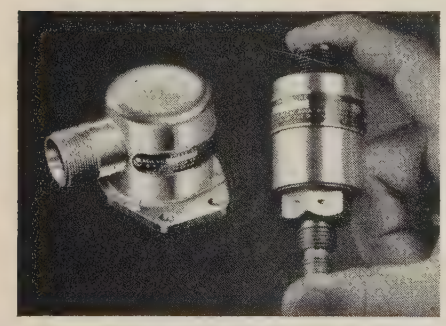

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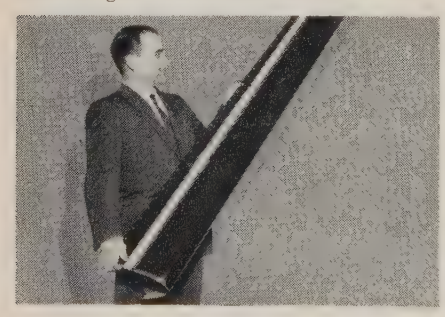

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Comparison of Weld Combinations*

Base Metals		Filler Metal	UTS (psi)	Test Temp. (deg F)	Location of Fracture
6061	6061	4043	43,100	RT	weld
6061	Tens 50 PM	4043	38,000	RT	weld
6061	6066	4043	45,600	RT	weld
Tens 50	Tens 50 PM	4043	41,100	RT	weld
6066	6066	4043	42,600	RT	weld
6061	6061	Tens 50	50,800	RT	6061
6061	Tens 50 PM	Tens 50	48,900	RT	Tens 50
6061	6066	Tens 50	49,700	RT	6061
Tens 50	Tens 50 PM	Tens 50	48,900	RT	Tens 50
6066	Tens 50 PM	Tens 50	50,000	RT	Tens 50
6066	6066	Tens 50	50,600	RT	weld
6061	6061	Tens 50	62,100	−320	weld
6061	Tens 50 PM	Tens 50	58,500	−320	Tens 50
Tens 50	Tens 50 PM	Tens 50	60,100	−320	Tens 50
6066	Tens 50 PM	Tens 50	61,100	−320	Tens 50

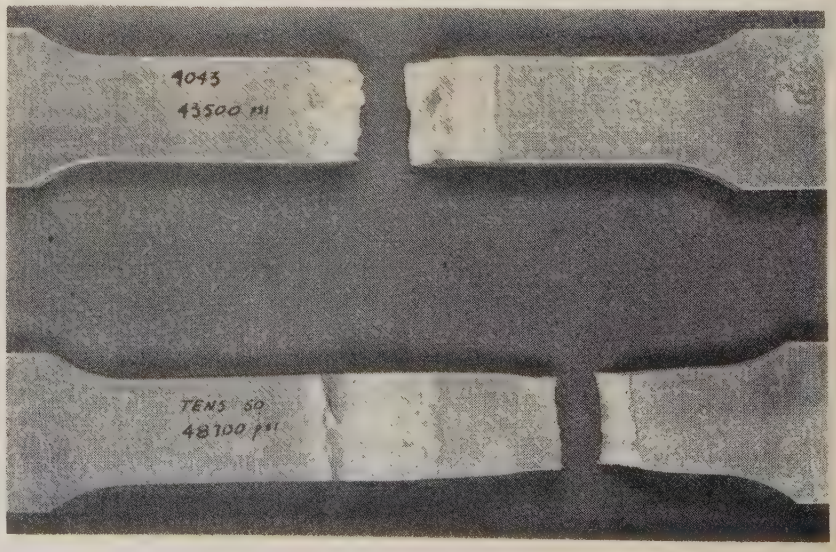
*Averages of 5-10 tests of ¼-in. plate with 90-deg V-joints after manual tig-welding, heat treatment, and flush machining of welds. Because of the heat treatment, the values for 6061 are higher than the ones usually given. "PM" indicates the permanent-mold-cast condition.

it can't be welded consistently with 6061 filler metal. Instead, an alloy with good hot ductility is needed.

The one generally used is 4043, which contains five percent silicon. As it has no magnesium in it, it doesn't respond to heat treatment. However, in fusion welding a certain amount of base metal is washed into the fused puddle. Therefore, when you weld thin setcions—say, up to ⅛ in.—the strength of a joint in 6061 made with 4043 is usually better than the base strength of cast 4043 would lead you to expect.

However, this dilution process also has its limits. In thick sections, a disproportionate amount of metal is deposited, and the analysis of the fused material approaches that of 4043. Generally, the base metal next to the weld loses magnesium

TENSILE specimens machined from weld specimens using ¼-in. 6061 base metal and heat-treated after welding to -T6. The specimen welded with 4043 rod (top) ruptured at 43,500 psi, the specimen welded with Tens 50 (bottom) at 48,700 psi.



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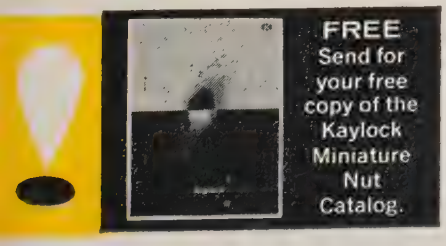

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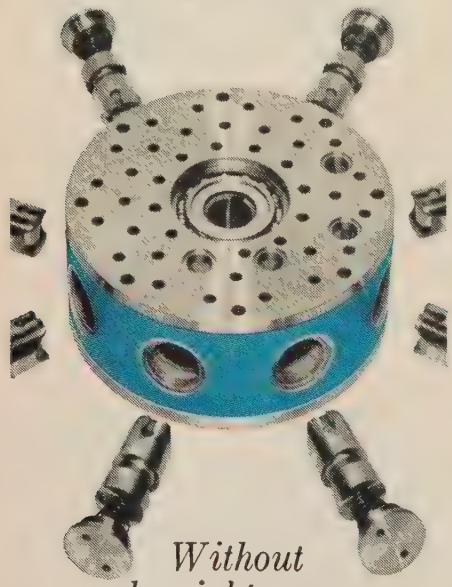
Sine Qua Non



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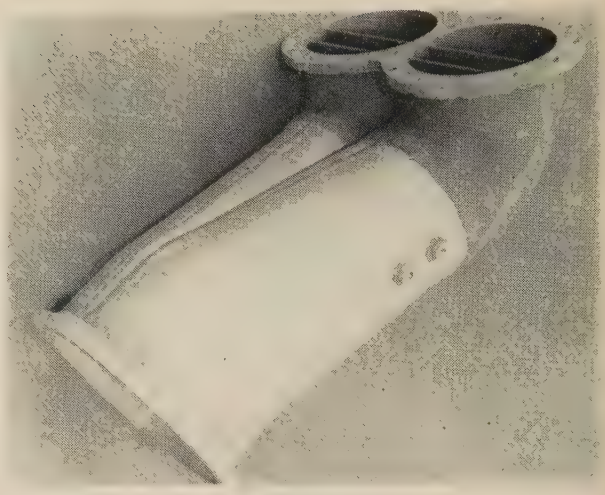

LARGE rocket fuel duct uses a cast Tens 50 elbow joined to a 6061 formed sheet extension, with a forged 6061 ring welded to the other end.

during the dilution process. Repair welding is advisable only twice—after that the strength drops off markedly.

Since the strength of the fusion zone in heat-treatable aluminum welds depends on the presence of aluminum magnesium silicide, which acts as the precipitation-hardening agent, an obvious solution would be to use a filler metal containing magnesium. Until recently, efforts along these lines have had only limited success. The development of Tens 50*, an NAA aluminum casting alloy, now has changed the picture.

Tens 50 is an aluminum-magnesium-silicon alloy, but the silicon eutectic has been modified by sodium. The presence of iron, normally an embrittling agent, has been controlled by the addition of a small amount of beryllium. In permanent mold castings of Tens 50, strengths of 50,000 psi are often obtained.

The fabrication of Tens 50 into welding rod has been completely successful, with good surface finish and excellent homogeneity. Early tests with tig-welding have shown that the material handles like 4043, except that its fluidity is somewhat better, thanks to the higher silicon content. Mechanical-property and X-ray tests also have been encouraging.

NAA has run an extensive weld test program to find the strengths to be expected from various metal combinations (see *Table*). At room temperature, a strength of 50,000 psi can be expected in Tens 50 welds with flush-machined bead reinforcement machined flush. At room temperature, the 10-20 per cent extra strength usually produced by the reinforcement is not needed with 6061, but is of advantage in welding 6066. It's also useful at cryogenic temperatures, at which it improves 6061 more than Tens 50 weld metal.

In designing joints in heat-treatable alloy parts, for which Tens 50 is used as the filler metal, no special precautions beyond those usual for 4043 are required. Joints should be set up for minimum root penetration and have ample room for filler metal. In flat butt joints up to 5/16 in. thick, a simple 45-deg bevel on each mating edge (with minimum land for fit-up) should be used.

Back machining recommended for best integrity

For larger thicknesses, J grooves generally are more economical. Again the minimum land compatible with fit-up should be used. For maximum integrity, back machining is recommended. Heat traveling ahead of the welding tip oxidizes the mating surfaces. This oxide won't break up as the weld puddle passes over it, and it's quite likely that a plane of weakness will be left. This plane is very thin and parallel to the direction of X-rays in the usual inspection shot, so that it may not show up. Gas backup, or the use of a backup flux, will help to reduce the formation of oxide on faying surfaces.

Castings preferably should be repaired in the as-cast or the annealed condition. Preheating to reduce distortion is suggested, especially for large or complicated parts. No strength allowance need

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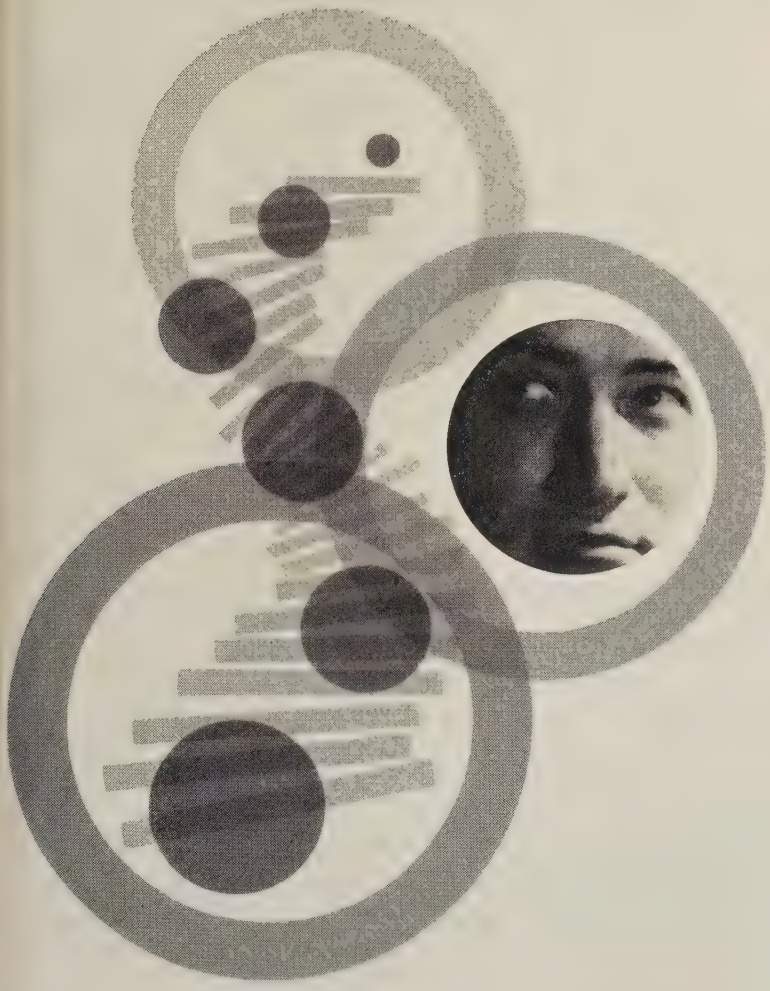

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be made for such repairs if made before heat-treat, since the weld metal will be stronger and more ductile than the original casting.

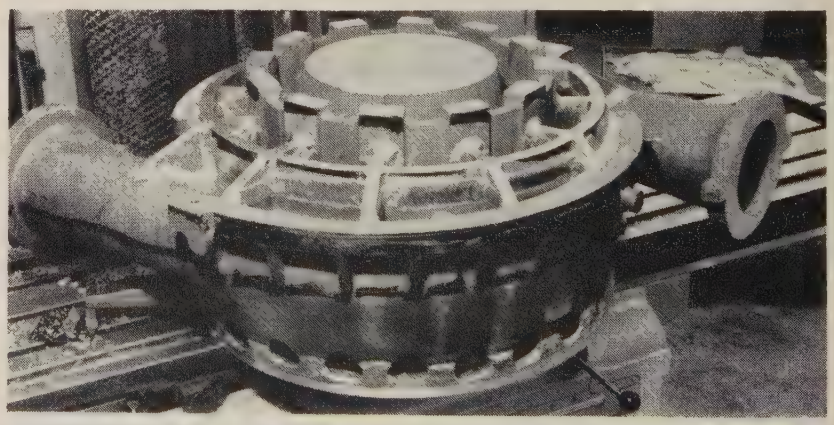
Cleanliness, as in all aluminum welding, is important. Parts should be clean, bright, and dry before welding. Brushing between passes is recommended. Tens 50 is fluid when molten and doesn't need puddling. Both manual and automatic tig-welding have been used with good results. A careful check has shown that the low beryllium content (0.1 per cent) causes no toxicity problem at all with Tig and oxy-hydrogen processes. In metal-inert-gas (mig) welding, the filler metal must pass down through the arc and therefore may reach much higher temperature in the molten pool than with other methods. This could result in magnesium loss by vaporization and loss of heat-treat response. For this reason and because of the beryllium content, welding for the time being is not recommended for Tens 50.

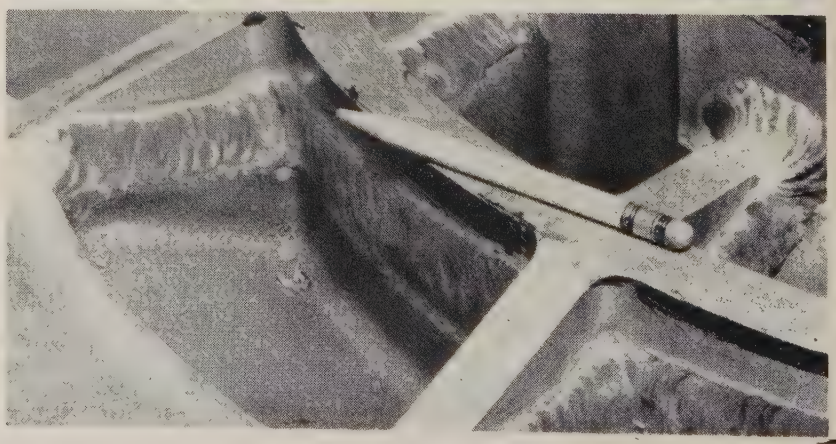
The heat-treatment of Tens-50 welds depends on the materials that are welded. Tens 50 and HP 356 castings need at least 12 hours' solution-treatment at 1000 deg F, followed by water quench. This treatment will, of course, also solution-treat the Tens 50 weld. Aging of Tens 50 weld metal is best done at 350 deg F for eight hours. This is a higher temperature and longer time than is usually specified for castings. Tens 50 welds will, however, develop strengths in excess of the cast structures even when given the casting aging treatment.

The extraordinarily fine micrograin size in the weld metal, the resulting of rapid chilling, markedly reduces the solution-treating time. However, to assure completion of the process, 1000 rather than 970 deg F should be used even when the weldment involves 6061 or 6066. Luckily, the added temperature improves both these alloys' mechanical properties after aging. Solution-treating periods as short as two hours have been used successfully. However, where circumstances permit, six hours has proved most effective in insuring maximum strengths.

Since Tens 50's strength depends

LARGE Tens 50 pump casting is being machined after modification. System changes required many structural changes in the casting design. These changes were made by welding in 6061 wrought material with Tens 50.





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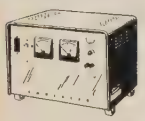

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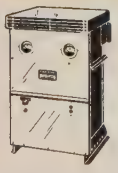

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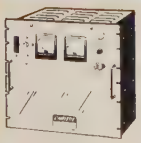

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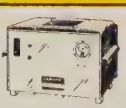

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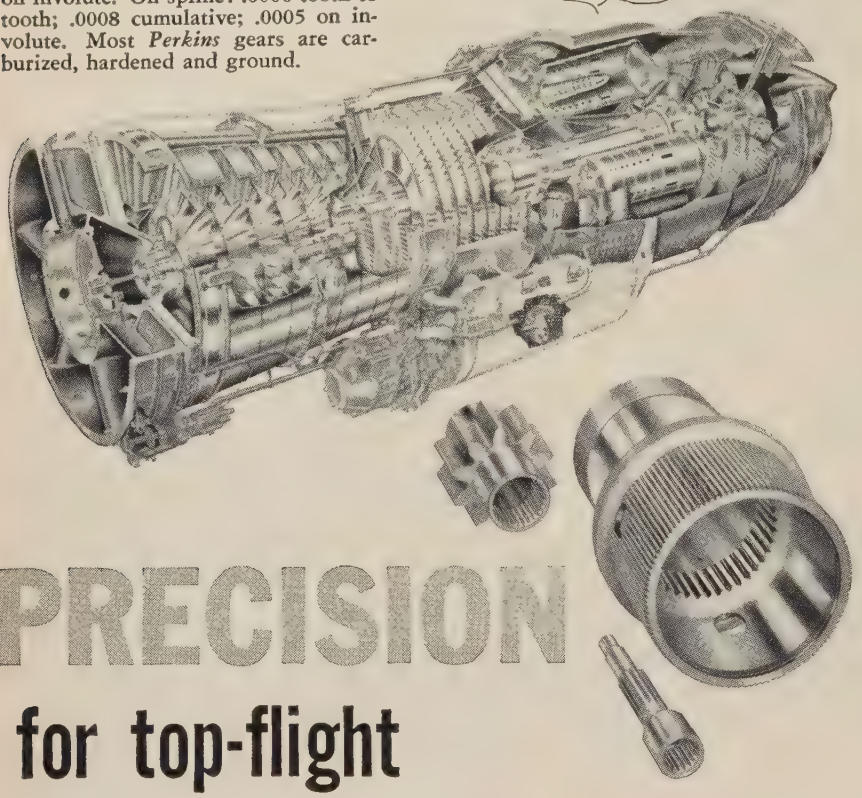

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on heat-treatment, it obviously should be used for joining assemblies for which this treatment is feasible. Fortunately, the magnesium-aluminum-silicon system is relatively sluggish in comparison with copper-aluminum and aluminum-zinc, so that extremely rapid quenching is not needed to gain full properties. Spray or fog quenching is suggested for assembly configurations that pose problems of thermal distortion. The part should be struck with water over all parts of its surface simultaneously—with as fine a spray as possible. Sections as thick as one inch have been thoroughly hardened by the spray-quench method.

The applications of Tens 50 weld rod quite naturally fall into three categories: repair of castings; modification of castings; and assembly fabrication of wrought, cast, or combined parts.

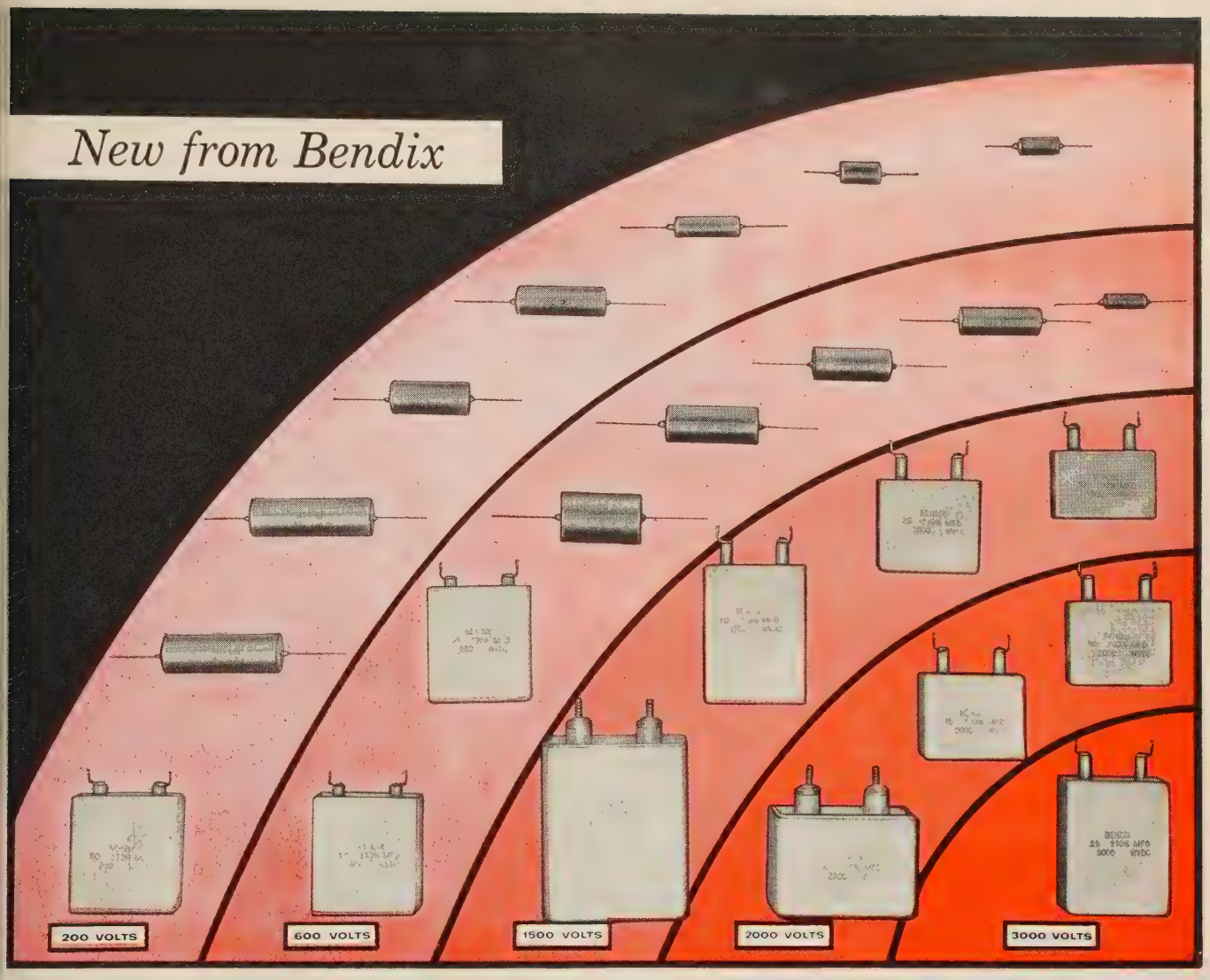
Spherical lox tank had several welds

Tens 50 weld rod has been used successfully in missile tankage. In one case, a roughly spherical lox tank five feet in diameter contained several circular welds, including circumferential welds joining a machine support ring to the tank halves. Sheets of 6061 were spun to shape and machined to thicknesses ranging from less than ⅛ to about 3/16 in. Automatic tig-welding was used. Underbead reinforcement was removed to reduce stress raising notches. The tank was fully heat-treated and then spray-quenched.

When a tank of this type burst in tests with liquid nitrogen, the rupture started at least six inches away from any weld in the wrought material. The tank had stretched to take several gallons more liquid than it would before pressurizing. The rupture stress calculated on the basis of the spherical-thin-wall formula was 50,000 psi.

Tens 50 makes it possible to repair and modify castings without sacrificing mechanical properties. As castings become larger, more complex, and much more expensive, the already extensive use of Tens 50 can be expected to increase greatly. The possibility of assembling simple castings into complex parts by welding and so saving pattern costs and reducing foundry problems is being considered. For composite assemblies of castings as well as wrought material, Tens 50 offers almost unlimited possibilities.

No. 36 on Reader Service Card



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High temperature capability and mica-like electrical characteristics enable the E-200 series to withstand extremely high orders of AC in small envelope size at all ambients under 200°C.

The new series is designed and manufactured to a Bendix specification which is patterned after the high reliability specification MIL-C-14157B, proposed.

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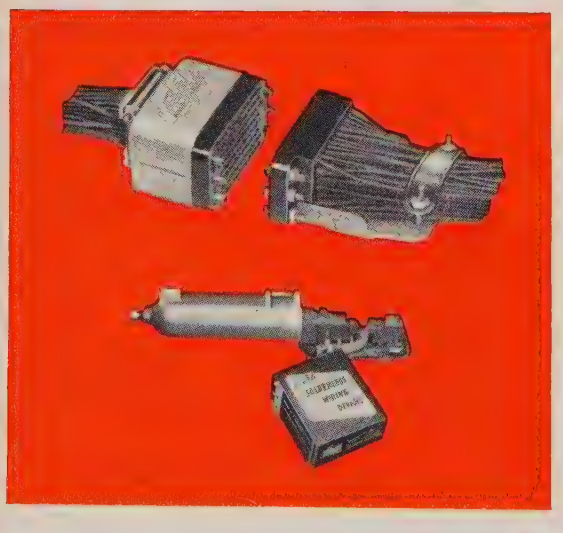

. . . and does it to the tune of more than 1,600 tape-fed AMPin-cert Pin and Socket terminations per hour . . . sometimes even more, depending on operator dexterity! Lower cost, semi-skilled labor can easily handle not only the automatic termination of leads but also the loading of AMPin-cert Connector blocks. A simple insertion tool helps fill connector cavities faster than a dentist trying to get away for an afternoon of golf. When you take these advantages and add the controlled pressure crimp backed by AMP's twenty years of experience in the field of solderless termination techniques . . . you have connector performance of maximum reliability at the lowest installed cost in the industry. This is the winning combination you get with AMPin-cert Connectors . . . available in all sizes and configurations. Get all the facts! Write today!

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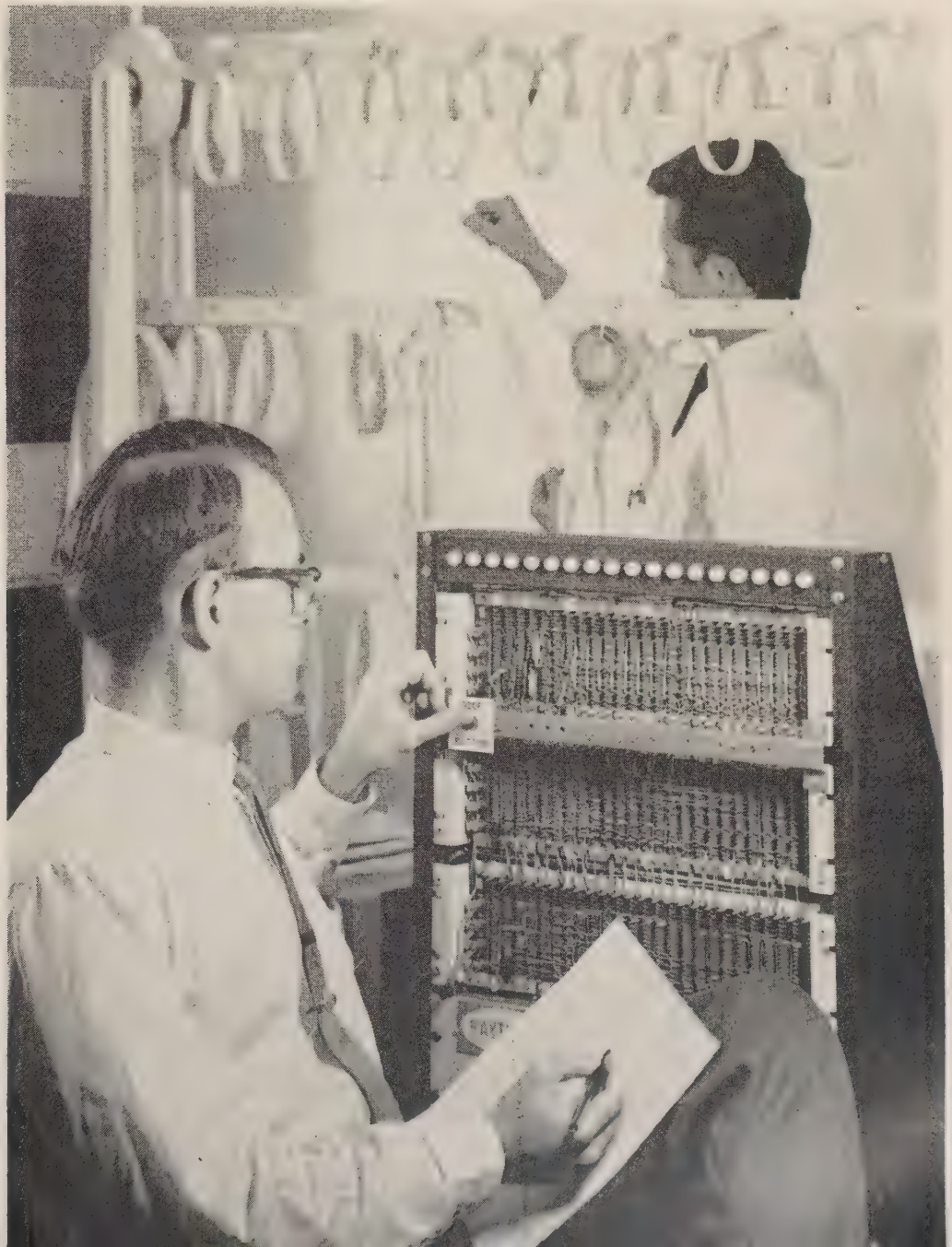
No. 38 on Reader Service Card

OCTOBER 1961

aerospace electronics

THE CYBERTRON, developed by Raytheon's Advanced Development Laboratory, learns by trial and error, relating new situations to past experience. Unlike a computer, the machine doesn't work logically from programed instructions. It determines its own method of attacking a problem, gives the answer and can tell how it was arrived at. The machine is taught by tapes (in background) that contain lessons.



ELECTRONICS INTELLIGENCE

REDEYE IR MISSILE USES UNIQUE FIN METHOD FOR IN-FLIGHT COURSE CORRECTION

The Redeye IR guided anti-aircraft missile will use a "revolutionary new steering technique" according to General Dynamics/Pomona, which is developing the weapon for the Army and Marine Corps. The unique steering system uses a single pair of fins near the missile's nose, canted at a 15 deg angle. The fins snap in and out as the missile revolves about its axis, steering the Redeye in whatever direction required to to keep it on target.

The IR seeker in the missile's nose guides it on a collision course to its target. Electronic circuits determine when the fins should snap out into the air stream. Since the missile revolves many times a second, a corrective turn in any direction is always possible whose magnitude is determined by the length of time the fins are extended, says Convair.

Redeye's IR guidance was developed jointly by General Dynamics/Pomona, the government, and Philco's Industrial Div.

RCA displays approach to universal transistor

An approach to a universal transistor was shown by RCA Semiconductor and Materials Div.—its new 2N2102 silicon transistor. The company claims that the device can perform the jobs of up to 40 per cent of the more than 2000 transistor types now on the market.

The transistor is made by "wedding triple diffusion and planar manufacturing techniques . . . in a single transistor." Some 55 electrical and mechanical tests must be conducted on the new transistor during production to insure high performance over its broad range of uses.

The 2N2102 is just being introduced into the military and industrial market. RCA expects to price it at about $12. Characteristics include: collector-to-base voltage, 120 V max; collector-to-emitter voltage (with base open), 65 V max; collector current, one amp max; dissipation at case temperature of 25 deg C, five watts max; storage temperature range, —65 to 300 deg C, operating temperature range, —65 to 200 deg C; gain-bandwidth product, 60 mc; switch speed (non-saturating mode), 30 nanosec max.

Ground equipment for Nimbus PCM telemetry will be furnished by Radiation Inc. under a million-dollar NASA contract. Radiation had previously been awarded a slightly larger (1.2 million) contract for the spaceborne telemetry components for the advanced meteorological satellite. The ground equipment will present oscillographic displays of selected data and compute, edit, and process the telemetered data. The design, says the company, will permit long periods of unattended operation.

GPL WINS CONTRACT FOR AF NUCLEAR GYRO

A contract for a nuclear gyroscope was awarded by USAF's Aeronautical Systems Div. to GPL Div., General Precision Inc. The R&D contract, for $285,000, is the second nuclear gyroscope award given to GPL; the division has been working on a previous one for USAF since 1958. General goal of the project is to develop instrumentation for harnessing the nucleus of the atom as a space or heading reference.

Voice-controlled equipment program

A speech analyzer-synthesizer program being run by Sylvania's Applied Research Laboratory for Rome Air Development Center could form the basis of future voice-operated typewriters, voice-programed computers, voice-dialed telephones and speech compression for transmitting wideband data over narrowband channels.

Sylvania researchers are using a computer to convert a set of numbers into

a tape recording of the human voice. The object of the program is to determine more efficient ways of mapping speech for automatic speech recognition systems.

Researchers are feeding taped voices into a digital computer where the sounds are mathematically analyzed and re-synthesized from the resulting numbers to reproduce the voice. All sounds are presented as the sum of 30-odd orthonormal (uncorrelated) functions with only the coefficients of the functions changing for the many nuances within a particular sound group.

SS/FM (single-sideband frequency modulation) telemetry will be used to measure flight-test vibration of the Saturn booster. First production contract for the ground-based portion of the radically new telemetering system was awarded to Dynatronics of Orlando, Fla.

A new technique, developed by engineers at the Marshall Space Flight Center, gives the SS/FM system a transmission channel capacity 15 times that of conventional equipment.

X-BAND AIRBORNE RADAR HAS "LONGEST RANGE"

An airborne weather radar designed by RCA's Aviation Equipment Dept. is claimed to be "the longest range and most compact airborne weather radar ever developed for commercial airlines." The new set, the AVQ-20, works in X-band, has a 180-mi range, is largely transistorized, and weighs around 45 lb. Composed of three units—antenna, receiver-transmitter, and indicator—the AVQ-20 has a stabilized antenna with 180-deg scan and an optional bright display tube indicator. To accommodate a variety of aircraft, the set is available with antennas of 12, 15, 18, 24 or 30 in. The quoted 180-maximum range is with the 30-in. dish only.

A noteworthy fact about the new airborne weather radar is that it operates in X-band. (RCA's current airline weather radar operates in C-band.) The latest Collins Radio weather radar is also in X-band. This shift to X-band by the airline radar makers may mean that the airlines made the wrong decision some six years ago when they selected C-band over X-band as the more appropriate wavelength region for their needs.

System sends speech in 150-cps bandwidth

A speech compression system developed by Melpar, Inc. can transmit speech in a total bandwidth of 150 cps. When digitized, the compressed speech signals can be transmitted at a 1000-bit-per-second rate, says Melpar.

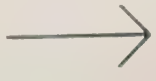
In its analog form, the compressor output appears as seven 20-cps-bandwidth, low-passed signals. For digitizing, each of the seven channels is sampled at 43½ cps to produce a single channel binary stream of 1000 bits per second.

The system was developed for the USAF's Aeronautical Systems Div. It weighs under 50 lb, occupies 1.3 cu ft, and is expected to find application in spectrum conservation, coded communication of speech, and long-range speech communications for global systems and manned space vehicles.

The electronics of USAF's three interceptors, the F-102, F-106, and F-101B, will be modified by the addition of infrared search and track, low-altitude-mission and electronic countermeasures gear and by redesign of the fire-control radar antenna and of the radar receiver's front end (to include a parametric amplifier).

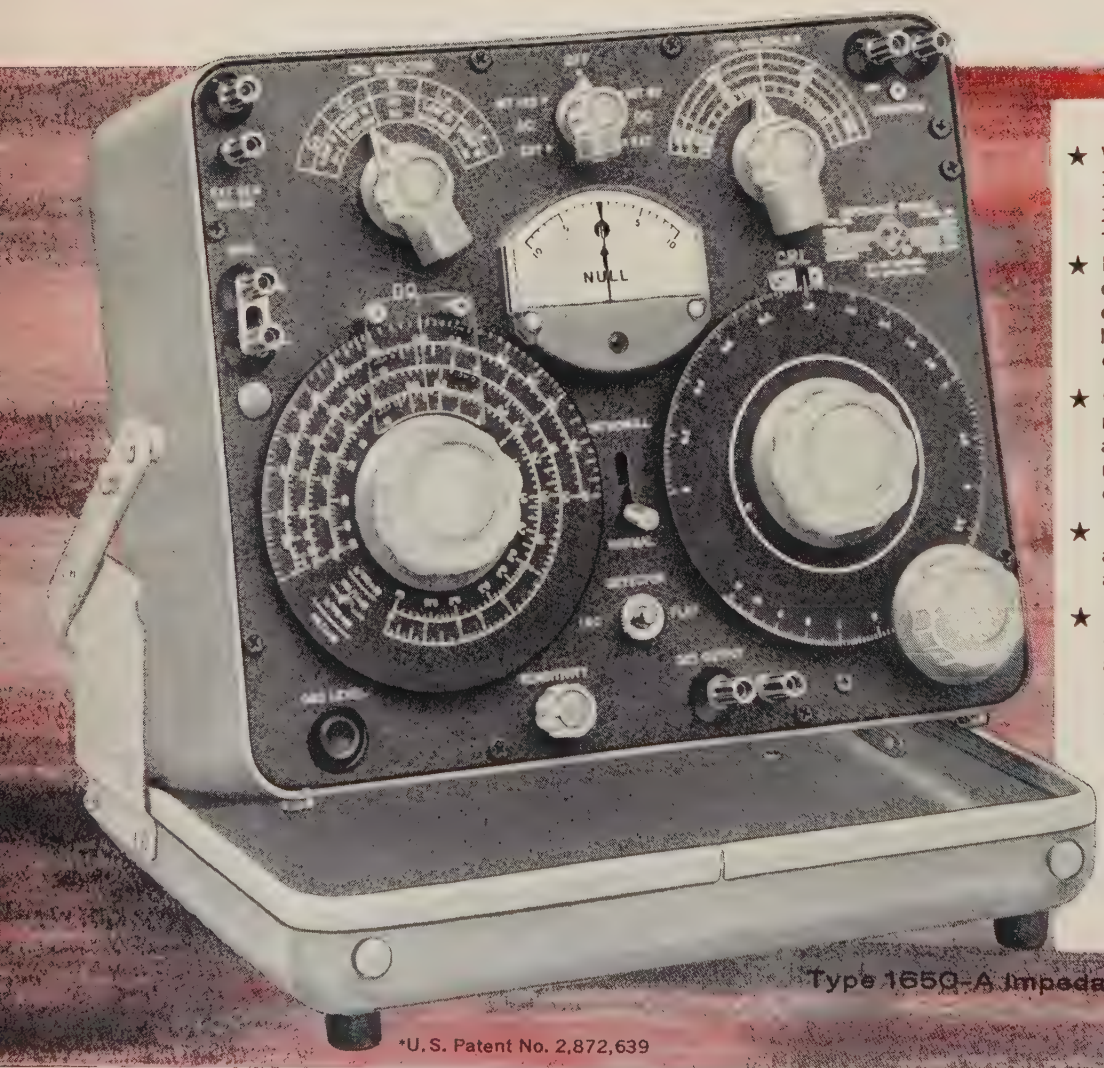
L-BAND DISTANCE MEASURING EQUIPMENT FOR AIRLINES

Wilcox Electric and Hoffman Electronics will jointly design, build and sell a a new model DME (distance measuring equipment) for commercial airline use. Two initial prototype models of the Wilcox-Hoffman model 833 DME will be com-



A FUNDAMENTAL INSTRUMENT

... useful for measurements ranging from interelectrode capacitance of semiconductors to impedance of transformers weighing several tons.



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pleted this month. Full production is scheduled by the summer of 1962.

The unit operates on 126 channels in L-band and will use nine electron tubes. All other active stages will contain transistors. Price will be in the $5-7000 range. This is Hoffman's first venture into the airline electronics market. Wilcox has been in this segment of the aerospace market for some time.

Alloyed-junction four-layer semiconductor

The first alloyed-junction, four-layer semiconductor, the Dynaquad, is now being introduced by Tung-Sol Electric, Newark, N. J. A germanium, three-terminal, PNPN structure in a standard TO-5 case, the Dynaquad is basically a two-position switch. Switching rate is in the megacycle range, with rise times on the order of 0.1 usec and an output voltage swing of 35 V.

In normal operation, the Dynaquad is turned on by applying a small negative pulse to the base. It will remain on after the signal is removed and is turned off by a positive pulse applied to the base or by dropping the collector current below the sustaining point.

A digital computer for space vehicles is being developed by Control Data Corp., Minneapolis, Minn. According to the company, it "is of high-reliability, general-purpose design, extremely small in size and weight" and "is designed to satisfy reliability requirements of unattended operation for over one year . . ."

SIMPLE SYSTEM FOR REMOTE RADAR WEATHER-DATA DISPLAY

Radar weather data can be remotely displayed with a rather simple system devised by a Stanford Research Institute engineer. Heart of the system is a mask with a grid of small holes that is placed over the viewing scope of a weather radar. As the radar trace passes under each hole in turn, light from the echo picture shows through if precipitation is present.

A light sensor is mounted above the mask to detect the presence or absence of light (precipitation) for each hole in the mask. This information is transmitted in simple digital form over telephone lines or radio to a remote station. The stations each have a weather map with a pattern of lights corresponding to the grid of holes on the weather radar scope. Thus, lights on the map are illuminated to conform to the light pattern on the tube grid, effectively transforming the precipitation pattern seen by the radar to the remote map. The system can also be modified to show intensity of the precipitation.

Can use moon as passive reflector

Use of the moon as a passive reflector is deemed practical by a number of British communications specialists as a result of experiments at Jodrell Bank and elsewhere. They believe that acceptable results could be obtained with a five-kilowatt transmitter and a 50-ft-diameter receiving and transmitting antennas. One limitation, they point out, is the 2.5-sec delay on a signal reflected from the moon.

A ground approach radar built by Laboratory For Electronics was bought by the SAAB Corp. of Sweden. LFE announced that the TNP/12 set was the first one sold to a private corporation. The rest of the sales have been made to the military market.

AUTOMATIC WIRE-WRAPPERS WIRE IBM COMPUTERS

Automatic, numerically controlled wire-wrap machines made by Gardner-Denver, Quincy, Ill. will be used by IBM for wiring its solid state computers. IBM is now using some of these machines in its Endicott, N. Y. plant and has ordered

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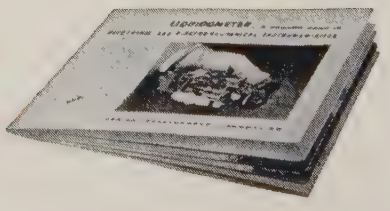

No. 40 on Reader Service Card

45 more for plants around the world. Directed by punched cards, the Gardner-Denver machine can attach 750 wires to a 20×30-in. panel in 2½ hours—about ten times faster than an experienced wireman.

The machine attaches wires to the panel by wrapping bared leads around plated bronze pins. It cuts each insulated wire from a spool, strips it, routes it along a certain path and wraps it onto two pins within five seconds—all automatically. If the machine makes an incorrect connection, it stops and remains stopped until a technician corrects the mistake and restarts it.

British P. O. discloses requirements for comsat

Requirements for a communications satellite issued by British Post Office include: 24-hr coverage between all ground stations for telegraphy and telephony, with 1000 telephone channels and one or two TV links. The Post Office is providing an experimental radio station on the extreme southwestern point of England to cooperate in NASA trials of its Relay communications satellite next year.

In France, Thomson-Houston has undertaken a joint study with Hughes Aircraft on the suitability of the Hughes synchronous satellite proposal for European needs.

The RAAF's Mirage III aircraft will use CSF's Cyrano fire control radar. The decision was announced after months of uncertainty due to conflicting statements by CSF and Ferranti Ltd., whose Airpass III radar was also considered. The Australian aircraft will now be almost identical with those for the French air force. South Africa is also interested in the Mirage.

UNIQUE PM METHOD LETS SYSTEM SEND 15,000 WPM OVER PHONE LINES

A data-transmission scheme developed by General Dynamics/Electronics can send 15,000 words per minute over ordinary telephone lines. Called Deft (dynamic error-free transmission) the system uses a unique type of phase modulation. Alphanumeric characters—including "frames" of computer language for direct communications between computers—are coded into phase relationships among simultaneously transmitted tones.

According to GD/E, the possible number of symbols that can be generated in the system is almost unlimited, so the difference between the very few characters in the English alphabet is so great that automatic character recognition is virtually error-proof. Neither dynamic logic nor storage circuits are needed for character recognition. Even greater error correction can be had by widening bandwidth, increasing power, or cutting transmission speed, the company points out.

Trailblazer IIs to study re-entry

Re-entry physics studies will be conducted by the Advanced Research Projects Agency with a series of capsule payloads to be fired to a 190-mi altitude and power dive back toward the earth. The rockets, with the payload as fourth stage, are known as Trailblazer IIs. They will be fired from Wallops Island, Va. by NASA and observed via optics and radar by Lincoln Laboratory scientists for ARPA, which is the sponsor.

Automatic checkout equipment will be built by Packard Bell Electronics for a French ballistic missile. PB recently signed a $350,000 contract with the French SEREB (Societe pour l'Etude et la Realization d'Engines Ballistiques) calling for the production of an automatic checkout system designed around a new computer-controlled systems evaluator concept developed by the California company. A larger system, based on the same concept, has been built by PB for the Saturn space booster.

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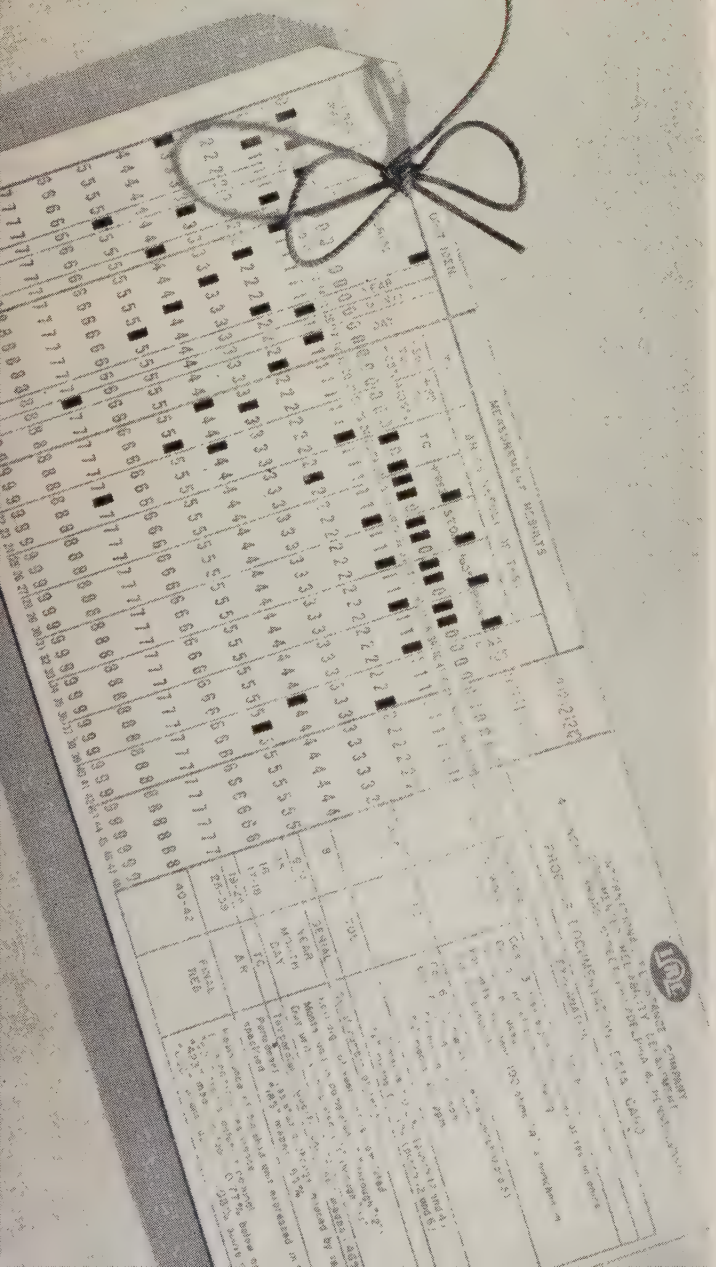

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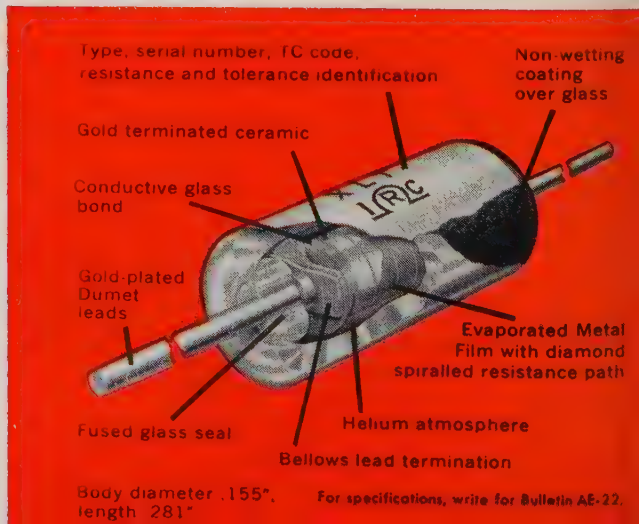
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For specifications, write for Bulletin AE-22.

Mobile types, many military strategists are coming to believe, will be the only effective ICBMs in the fairly near future. They believe that underground silo systems like the present Minuteman are quite vulnerable to precisely guided ballistic missiles with very-high-energy warheads.

The railroad-launched ICBM does not appear to be the answer to this problem. It's almost impossible to give it the security it needs without tying up a huge force of men to guard every foot of railroad it might use. Future mobile ICBMs most likely, will be carried by aircraft, surface ships, submarines, and special ground vehicles that can roam over rough, barren terrain. In the last case, determining the exact coordinates of the launch point might lead to some problems, although certainly not on the scale of those of the Polaris missile system. Solutions might be a precise LF-to-MF radio grid laid down over the wander area and/or special surveyed bench marks in various locations.

With world tensions mounting and rumors filtering through the Iron Curtain that the Reds now have an anti-ballistic-missile capability, chances look very good for the White House's ordering the Nike-Zeus into production despite fierce objections to the system in many parts of the Defense Department. Enough Zeus installations to protect about one-third of the U.S. population would cost an estimated $8-14 billion. If ordered in this quantity, Zeus would constitute the largest defense contract in history.

Whether or not Zeus production is given the green light by President Kennedy will depend largely on how the missile performs in its tests at Kwajalein early next year. In these tests, Zeus will attempt to knock out Atlas missiles—complete with ECM and decoys—launched from Vanderberg AFB, Calif.

The poser that the tests, it is hoped, will answer is: How well can Zeus discriminate against decoys? Many in DOD and industry believe that Zeus will prove ineffective against sophisticated decoys that closely resemble a ballistic warhead. The Army, on the other hand, claims that its studies show that the only thing that closely resembles a re-entering warhead is another warhead.

Mating of Arpat and Zeus is being talked about in defense circles as a possibility for the future and as a reason for giving Zeus the go-ahead. The Arpat (*A*dvanced *R*esearch *P*rojects *A*gency *t*erminal) system is being built in trial hardware form. Its actual weapon is a group of circularly or elliptically homing 50-lb missiles, or "darts," fired from a carrier vehicle that is launched into the atmosphere into the vicinity of a re-entering warhead or group of warheads.
Like Zeus, Arpat has a ground complex consisting of acquisition, tracking, and discrimination radars, computers, and data processers.

Barring a breakthrough, we cannot expect any other active anti-missile system besides Arpat and Zeus to be anywhere near operational status within the next decade. Bambi (*b*allistic *a*nti-*m*issile *b*oost *i*ntercept) is still in the study phase and is "way out" in terms of the present state of the art—it would use an armed observation satellite to kill ICBMs during their powered-flight phase.

Meanwhile the anti-ICBM problem grows more complex. For instance, new-generation ICBMs probably will have maneuverable warheads.

Side-looking radar, developed by the University of Michigan's Institute of Science & Technology for the Army,* is one of the cleverest designs in recent aerospace electronics history. Essentially it synthesizes a very large antenna from a much smaller dipole array by means of the forward motion of the aircraft and the phasing of the antenna elements. Theoretically the azimuth resolution of the synthetic antenna is independent of range and radar frequency, the Michigan scientists found out.

Information is displayed by generating a line scan on a CRT and recording the consecutive sweeps on a tape or film whose speed is proportional to the aircraft's groundspeed. The radar PRF is also groundspeed-controlled to maintain a constant film exposure. The radar antenna is kept perpendicular to the ground by a combination of drift-angle information from a Doppler navigator and a gyro mounted on the antenna base.

Electron tubes are blamed unjustly, at least in airline electronics, is the surprising conclusion of Arinc after three years of tests of tube performance in flight operation. The tests involved more than 10 million tube-hours and more than 500,000 equipment hours.

Arinc examined tubes that had been replaced by airline maintenance technicians and found that most of them still fell within the factory tests limits for new tubes. It concluded that the airlines use only one-third of the possible life of these tubes. Generally it believes that too many good airline tubes are being removed and discarded in preventive maintenance inspections. It also has vastly increased its already healthy respect for the electron tube. It believes that good tubes are often replaced with higher-gain ones of the same type to make up for composite out-of-tolerance drifts in passive components.

Since a tube can be removed and replaced easily, technicians try this method first instead of trouble-shooting the stage. When the newly inserted tube gives the necessary extra gain needed, the fault is recorded as being due to tube malfunction when the real offender might be an unknown R, C, or L, Arinc maintains.

Because of its strengthened faith in electron tubes, Arinc is cautioning its airline owners to be wary of the "New Look" solid-state VHF communications and navigation equipment being designed by airline electronics suppliers. It claims that the airlines must get at least a fourfold reliability improvement over tube equipment to make the transition to solid-state equipment worth while.

* See Military Electronics", "A High Resolution Radar Combat Surveillance System;" *Trans. Mil. Electronics,* Apr. '61.

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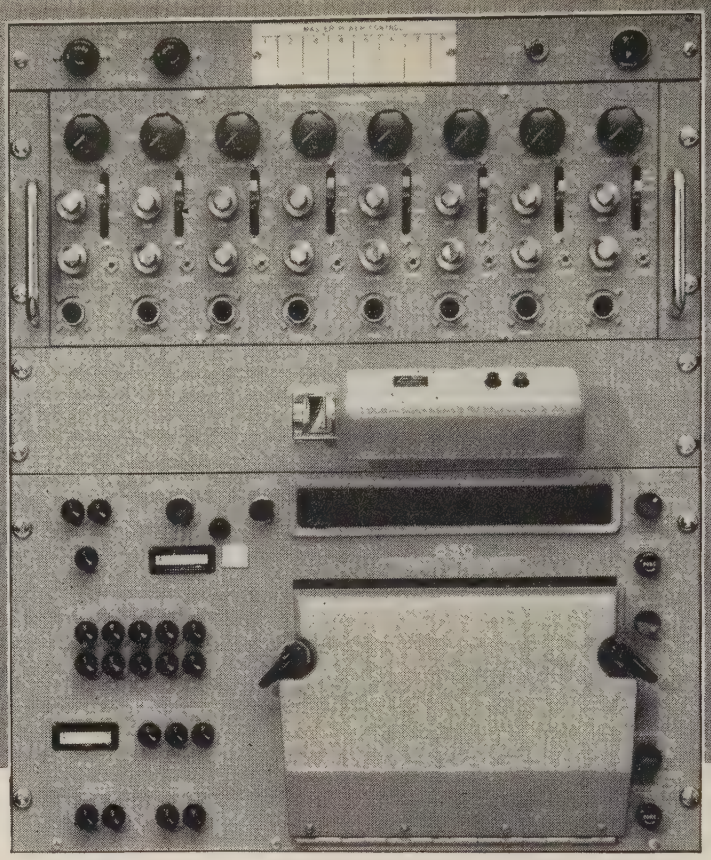
DC to 5000 cycles over an amplitude of 4" peak to peak



NEW SANBORN "650" SYSTEM OFFERS DIRECT READOUT, 8 TO 24 CHANNELS, ALL SOLID STATE CIRCUITS, FOR RACK MOUNTING OR INDIVIDUAL CASES.

Here's the *one* system that lets you record inputs from DC to 5 KC within 3 db at 4" peak-to-peak amplitudes, without changing galvanometers. The "650" system consists of an 8-channel medium gain, general purpose amplifier unit driving a high speed, high resolution optical oscillographic recorder. It can be easily built into your system, packaged in a mobile cabinet or housed in individual cases. The single-chassis, 7" high amplifier module has 8 separate channels, *complete from floating and guarded inputs to galvanometer outputs;* each channel comprises a front end modulator and input transformer, carrier amplifier, demodulator, filter and driver amplifier. Power Supply and Master Oscillator Power Amplifier are built-in. All amplifier elements are plug-in transistorized units for easy servicing.

Immediately readable recordings are made on 8" wide daylight-loading ultra-violet-sensitive charts which require no chemical development. Features of the 12¼" high recorder unit include 9 electrically controlled chart speeds from ¼" to 100"/sec; calibrated monitoring screen; automatic trace identification and timing lines at 0.01 or 0.1 sec. intervals; amplitude lines spaced 0.1" apart which can be blanked from ¼, ½, ¾ or all of chart. Recorder is available with an 8-, 16- or 24-channel galvanometer block which is then equipped with the number of galvanometer elements desired by the customer. Both the Recorder and Amplifier are also available as individual units for use with other equipment.

SENSITIVITY 20 mv input gives 8" deflection; 12 attenuator steps to X5000, smooth gain control.

INPUT RESISTANCE 100,000 ohms all ranges, floating and guarded; DC source resistance must be kept below 1000 ohms on mv ranges only.

COMMON MODE PERFORMANCE Rejection at least 140 db at DC, tolerance to ±500 volts, max.

GAIN STABILITY Better than 1% to 50° C. and for line voltage variation from 103 to 127 volts.

LINEARITY 1½% of full scale (8 in.)

NOISE 0.02" peak-to-peak, max.

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POWER REQUIREMENTS 103-127 volts, 60 cycle AC, 625 watts

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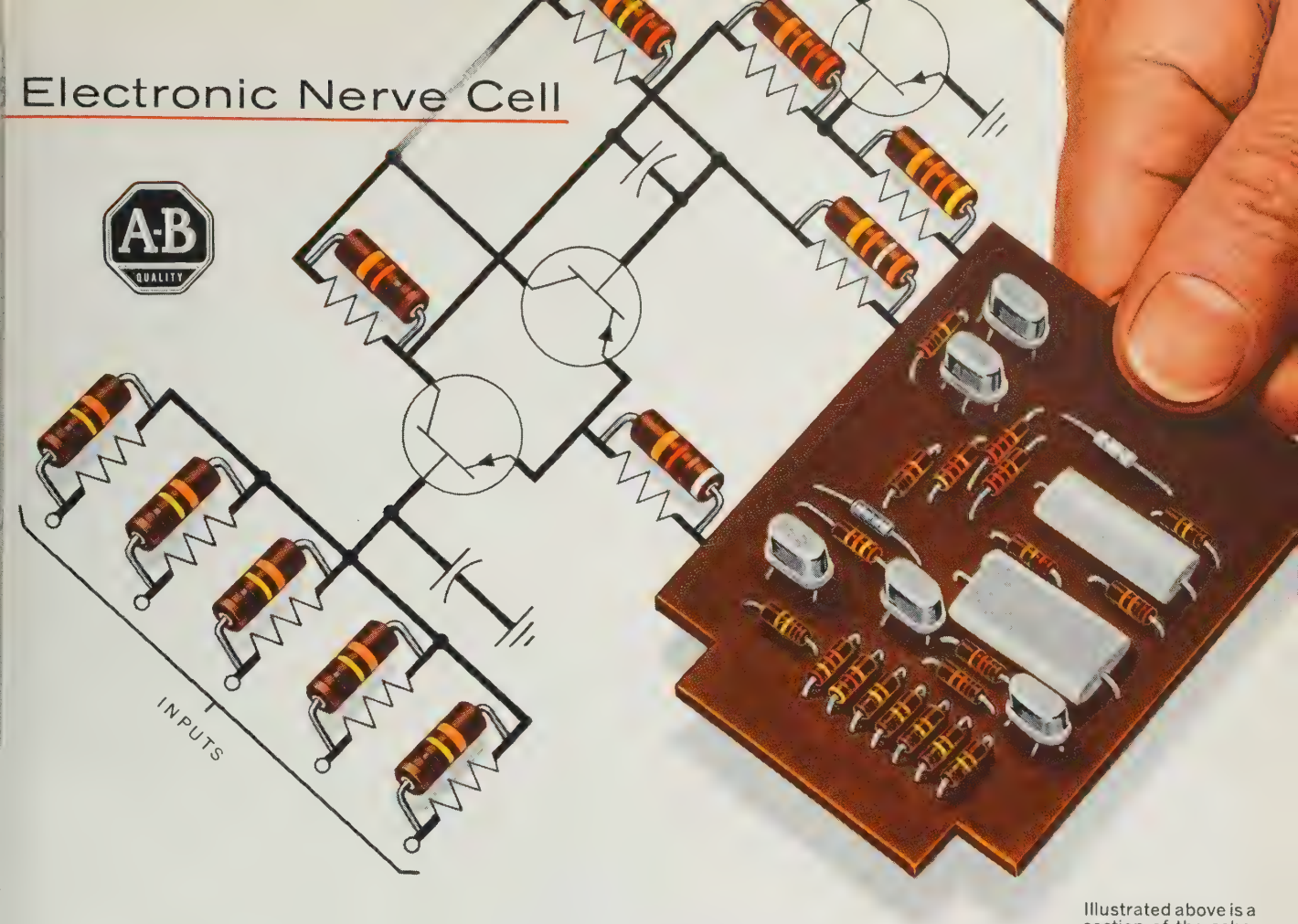

Illustrated above is a section of the schematic diagram for the artificial neuron (nerve cell).

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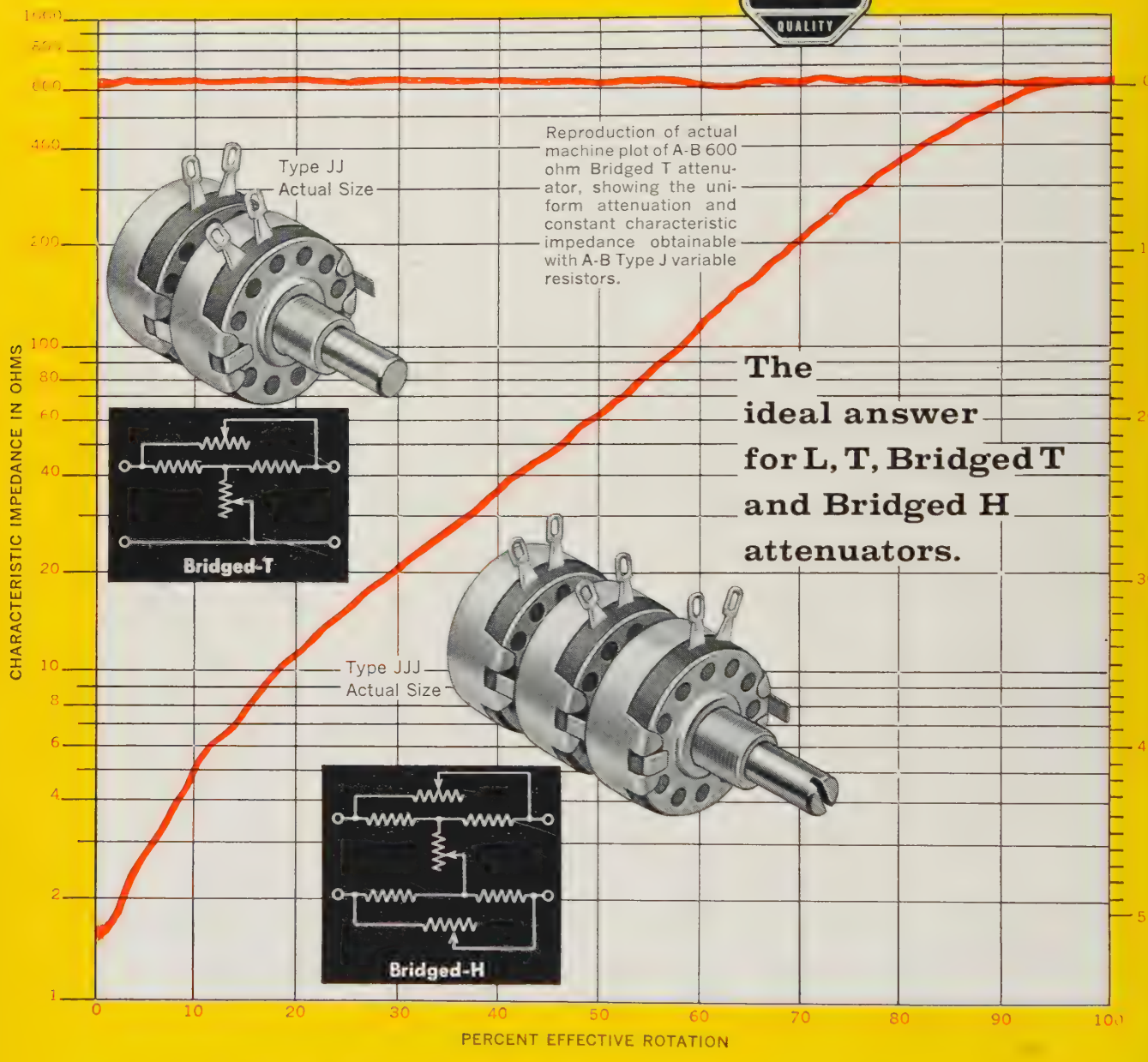
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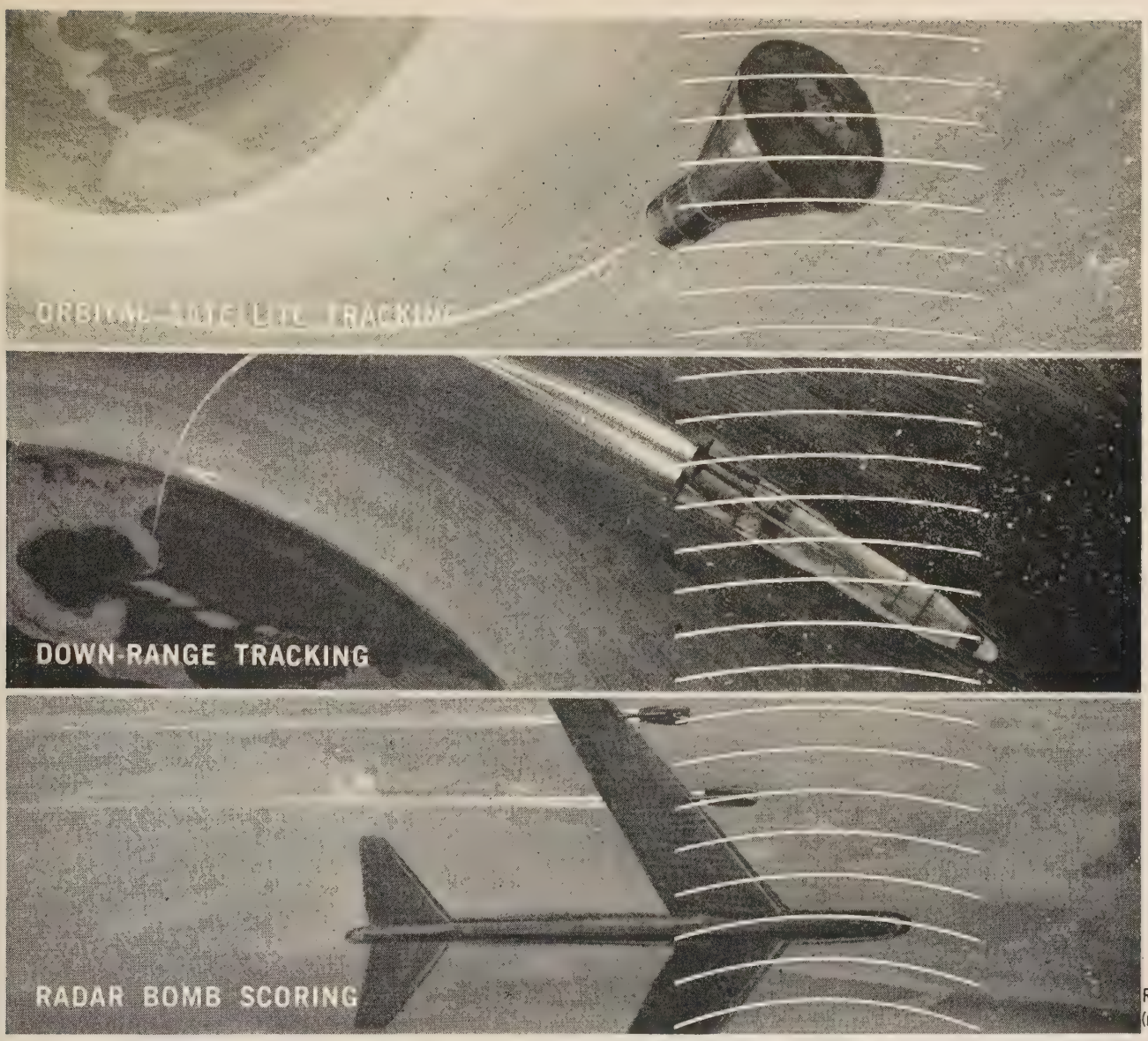

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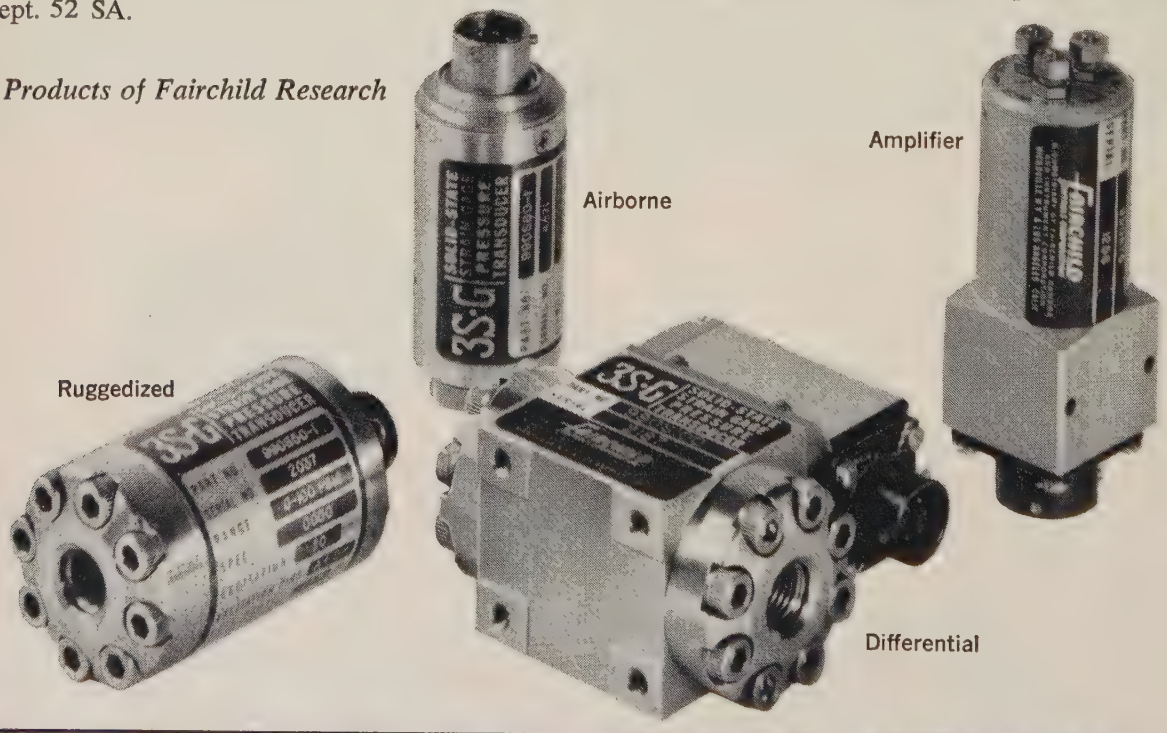

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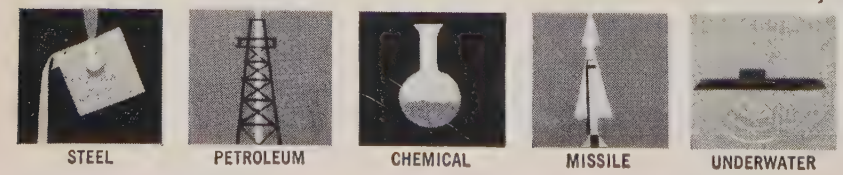

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Case studies in efficient heat transfer

by **A. D. Kraus,** Research Engineer, Sperry Gyroscope Co.*

FORCED CONVECTION is the most widely used mode of heat transfer in cooling airborne electronics. Conductive and radiative cooling both usually involve penalties that outweigh their advantages—the former requires outsize structures, for instance, for significant heat dissipation and the latter is effective only at source temperatures that are generally well above the maximum allowable component temperatures.

For convective cooling, many coolant fluids are available. Each has a range of heat-transfer coefficients (h), which can be generalized as:

- natural, or free, convection using air or some other gas at atmospheric pressure—h = 0.4-2.0;
- forced convection using air or some other gas—h = 1-50;
- forced convection using a liquid—h = 10-500;
- nucleate boiling—h = 100-1000.

When the heat-dissipating areas are small and there is quite a lot of heat to get rid of, a liquid coolant is

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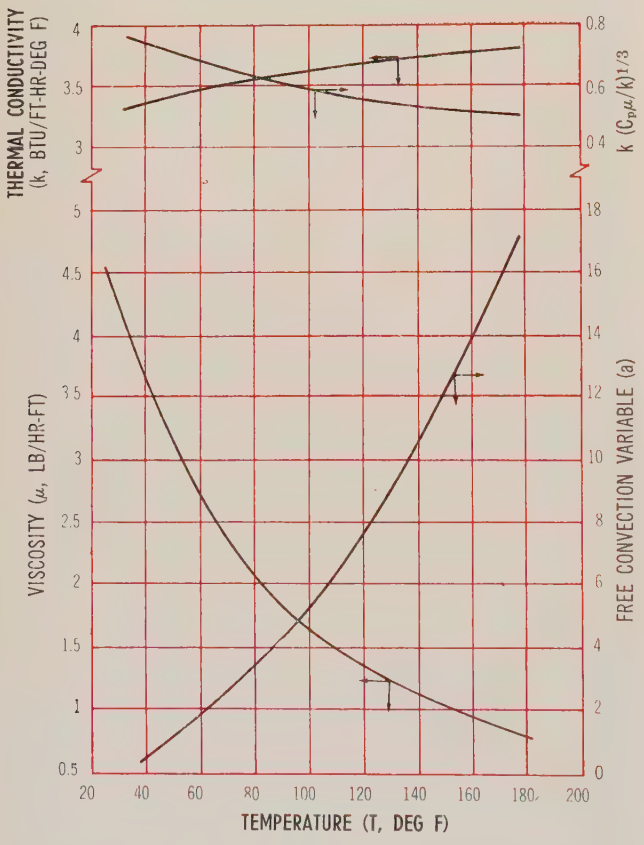


FIGURE 1: Thermal properties of water. The specific heat of water is constant at 1.00 btu/lb-deg F. (From "International Critical Tables.")

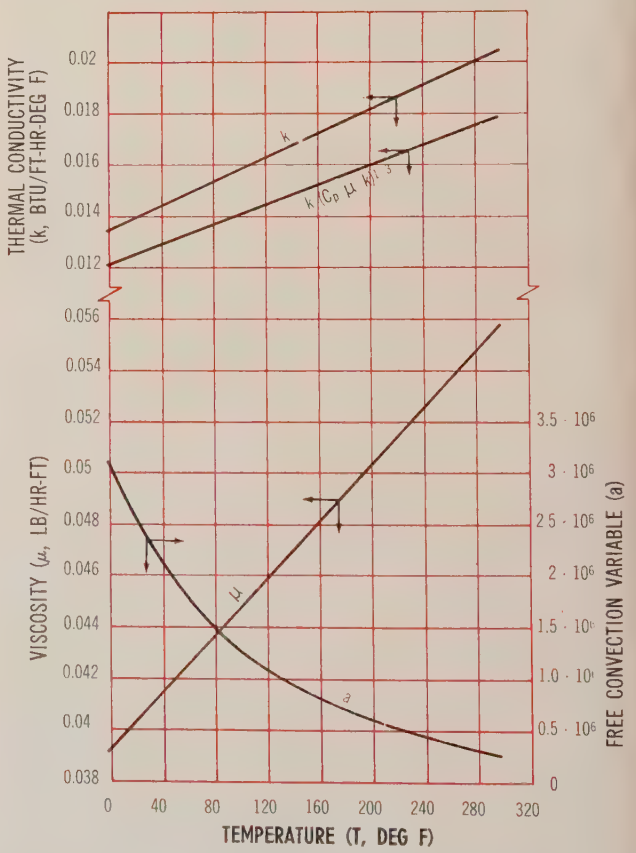


FIGURE 2: Thermal properties of air. The specific heat of air is constant at 0.241 up to 500 deg F. (From Perry, "Chemical Engineer's Handbook.")

IN BRIEF

This is the second article in a two-part series on heat-transfer design for air- and spaceborne electronics. Using cooling case histories for a TWT, transistors, vacuum tubes, and a high-voltage power supply, it shows how the analytical methods explained in the first article are applied in practice.

Generally liquid cooling is used whenever high heat dissipation is required for a relatively small area. The typical solution relies on forced-convection heat transfer, with air as the heat absorbent and, if necessary, carefully designed auxiliary fins on the hot surfaces. The most effective fins, experience shows, take the form of longitudinal structures with rectangular, triangular, or parabolic surfaces.

required. Water would be excellent if it didn't have poor electric properties and didn't freeze at a temperature well within the standard aerospace environmental extremes (*Fig. 1*). The designer therefore must go to synthetic fluids like FC-75, OS-45, and DC-200. When liquid cooling is not required, air is readily available, whose heat-transfer characteristics approach those of nitrogen and other pure gases (*Fig. 2*).

The heat-transfer coefficient of a coolant fluid is a function of the fluid's density, viscosity, thermal conductivity, and specific heat, as shown, for example, by the relationship for a fluid flowing through a duct, or confined channel:[1]

$$h = A(k/d)(\rho Vd/\mu)^{0.8}(C_p\mu/k)^{0.4}.$$

Fluids can be compared on the basis of this relationship. For the case of several fluids passing through

(1) The constant A in this case does not equal 0.023, because we are forcing the relationship by using 0.4 as the exponent on the Prandtl number.

Nomenclature

A	flow area (sq ft)
A_p	optimum profile area (sq ft)
α	free, or natural, convection variable (a function of temperature)
b	length of fin (ft)
C_p	specific heat (btu/lb-degF)
d	inside diameter of coolant passage (ft)
d_e	equivalent diameter (ft)
d_i	inside diameter (ft)
d_o	outside diameter (ft)
F	heat transfer parameter ($F = e^f$)
G	mass flow rate (lb/sq ft-hr)
h	heat transfer coefficient (btu/sq ft-hr-deg F)
I_0	modified Bessel function, first kind, zero order
I_1	modified Bessel function, first kind, first order
j	heat transfer parameter
k	thermal conductivity (btu/ft-hr-deg F)
L	length of coolant passage (ft)
m	fin performance factor (reciprocal feet)
n	number of fins
P	perimeter of heat transfer surface (ft)
P_r	Prandtl number
q	heat flow (btu/hr)
q_o	heat flow into fin (btu/hr)
R_e	Reynolds number
S	surface area for heat transfer (sq ft)
S_b	base surface (sq ft)
S_f	fin surface (sq ft)
S_T	total surface (sq ft)
T	temperature (deg F)
T_A	average air temperature (deg F)
T_B	average bulb temperature (deg F)
T_m	mean temperature (deg F)
T_S	dissipator temperature (deg F)
T_1	inlet air temperature (deg F)
T_2	outlet air temperature (deg F)
V	velocity of coolant (ft/hr)
W	flow rate (pph)
δ	thickness of fin (ft)
ζ	heat transfer parameter
η	fin efficiency (per cent)
θ	temperature difference beween fin and surroundings (deg F)
θ_o	temperature difference between fin and surroundings at base (deg F)
μ	viscosity of coolant (lb/hr-ft)
μ_w	viscosity of fluid at wall temperature (lb/hr-ft)
ρ	density of fluid under standard conditions (lb/cu-ft)

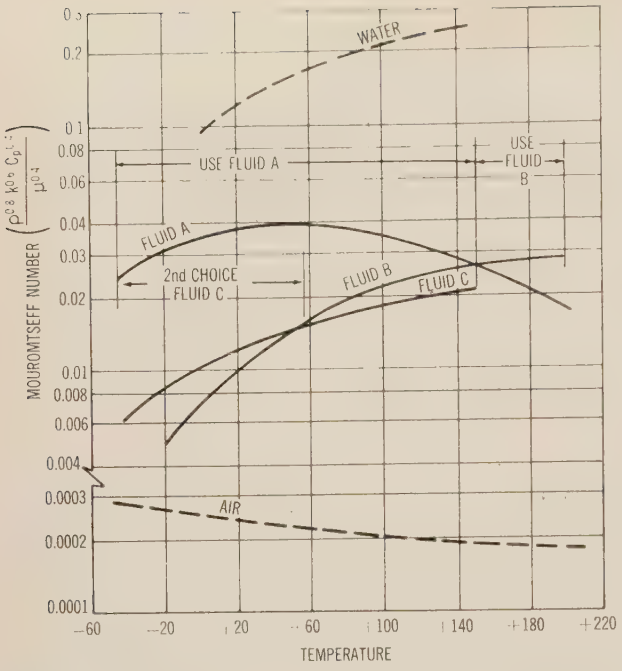
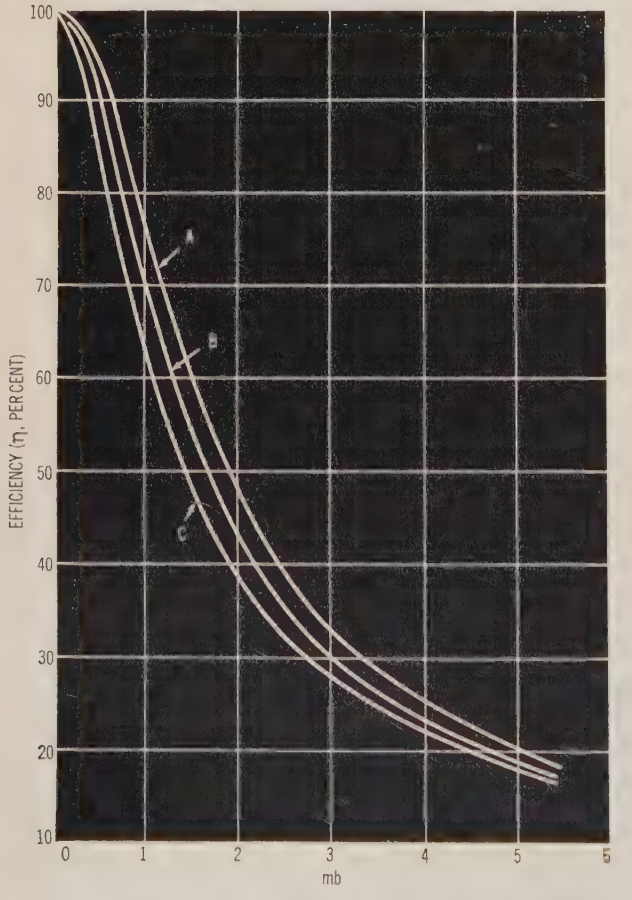


FIGURE 3: Mouromtseff number vs temperature for three liquid coolants, all of which are almost two orders of magnitude better than air.

FIGURE 5: Efficiencies of rectangular (A), triangular (B), and parabolic "concave" (C) longitudinal fins.



exactly the same configuration at exactly the same velocity, h becomes a function of, and proportional to $\rho^{0.8}k^{0.6}C_p{}^{0.4}/\mu^{0.4}$. This "Mouromtseff number" is a grouping of physical and heat-transfer properties and is a function of temperature. (Unlike the Reynolds, Prandtl, Nusselt, and other numbers, it is not dimensionless.)

With the Mouromtseff number, a fluid can be evaluated precisely, for this number reflects both the fluid properties that affect h and their relative weights. A simple comparative plot of Mouromtseff number vs temperature shows the temperature range over which one fluid might be preferable to another (*Fig. 3*).

Case 1: Traveling-Wave Tube

The high powers handled by TWTs lead to high heat dissipation and usually require a forced-convection cooling system. We will take the case of a TWT that generates 300 W and has a cylindrical heat dissipator 1½ in. in diameter and three inches long. The dissipator temperature is to be held to 175 deg C, or 347 deg F, by forced air cooling at a flow rate of 1.6 ppm and a flow temperature of 80 deg F.

Our design of a heat-dissipating system begins with the surface area, which is:

$$S = \pi \times 1.5 \times 3 + (\pi/4)1.5^2 = 15.9 \text{ sq in.} = 0.1104 \text{ sq ft.}$$

The required heat-transfer coefficient then is:

$$h = \frac{q}{S\Delta T} = \frac{300 \times 3.413}{0.1104(347 - 80)} \approx 34.8 \text{ btu/sq ft-hr-deg F.}$$

Unfortunately, this value is just a little too high for forced air cooling.

Because our design calls for cooling air at a specific temperature, the temperature differential between components and inlet air is fixed. The flow rate is fixed, too, and conceivably may not yield a coefficient high enough for heat transfer without overheating the TWT. The parameter that can be controlled is revealed by the rate equation, which yields:

$$q = hS\Delta T.$$

As q and ΔT are fixed, it is S that must be adjusted if we want h to have a reasonable value. In the case of our TWT, S can be increased by the addition of fins, which may take any of a variety of forms (*Fig. 4*). For these fins, configuration and placement on the heated surface are of prime importance—a large number of fins by itself does not insure an efficient design.

When a fin is operating at a higher temperature than the surrounding environment, heat flows from the hot base surface into and then along the fin. At the same time, heat is transmitted from the fin to the environment, so that there is a falling temperature gradient over the fin surface from the base to outer fin edge.

Because of this gradient, the fin operating temperature clearly ought to be chosen in terms of an average for the entire fin surface[2]. This average is difficult to calculate, however, and it is much easier to use the concept of "fin efficiency," which relates a fin's base temperature and surface area in a very simple fashion. A fin efficiency of 65 per cent, for example, means that the base temperature can be taken as the average temperature if the fin surface is reduced to 65 per cent of what it really is. Or, to put it another way, that the average temperature of the entire fin surface equals 65 per cent of the base temperature. No matter which of these two interpretations of fin efficiency you use in your

(2) It would obviously be a mistake to apply either the base temperature or the edge temperature to the entire fin surface. The former naturally exists only at the junction of fin and heated body; the latter exists only at the fin edge and, being a minimum, would lead to an excessively heavy design.

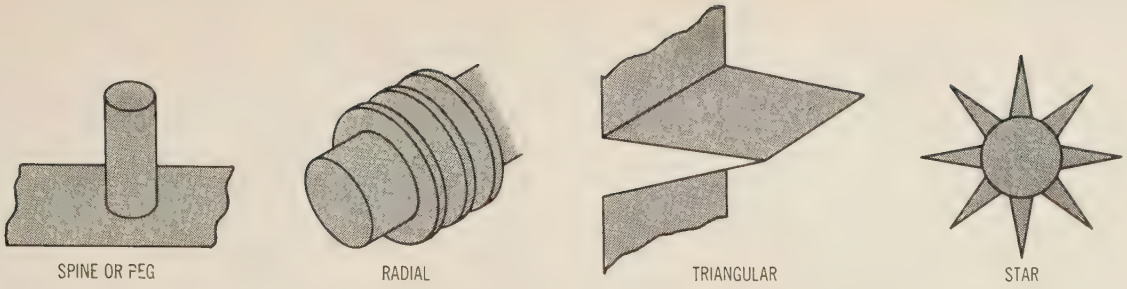


FIGURE 4: Typical fins for heat-transfer application.

calculations, you will get the same results as you would had you stopped to calculate the average temperature of the entire fin surface.

Table I and *Figure 5* give the equations for the temperature profiles, heat flows, efficiencies, optimum dimensions, and required profile areas of three longitudinal fins that are easier to produce than any other fins and have high efficiencies than radial fins. *Table II* gives the trial-and-error procedure by which a fin design for cooling our TWT can be evolved on the basis of the correlation formulated by DiLorenzo and Anderson (*Fig. 6*)[3].

Case 2: Air-Cooled Power Transistor

Fins can be used to advantage in cooling power transistors and other semiconductor devices (*Fig. 7*). Many transistors can be arranged for series-parallel cooling, with the cooling duct that houses the fins acting as a structural, or mounting, member. Each transistor mounts on its own cooler, since the transistor case is frequently the collector or emitter electrical terminal and must be isolated from ground.

(3) DiLorenzo, Anderson, "Heat Transfer and Pressure Drop of Liquids in Double Pipe Fin Tube Exchanger;" *Trans. ASME*, vol. 67, p. 697, '45.

Table I: Properties of Three Longitudinal Fin Configurations

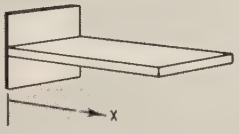
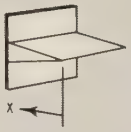
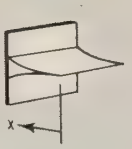
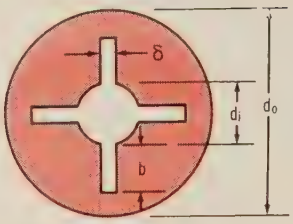
	Rectangular Profile	Triangular Profile	Parabolic Profile
			
Temperature pattern [T(x)]	$\theta = \frac{\theta_o \cosh m(b-x)}{\cosh mb}$	$\theta = \frac{\theta_o I_o(2m\sqrt{bx})}{mI_o(2mb)}$	$\theta = \left(\frac{x}{b}\right)^{-1/2 + 1/2\sqrt{1+(2mb)^2}}$
Heat flow into fin	$q_o = k\delta Lm\theta_o \tanh mb$	$q_o = \frac{2h\theta_o I_1(2mb)}{mI_o(2mb)}$	$q_o = \frac{k\delta\theta_o}{2b}\left[-1+\sqrt{1+(2mb)^2}\right]$
Efficiency	$\eta = \frac{\tanh mb}{mb}$	$\eta = \frac{I_1(2mb)}{mbI_o(2mb)}$	$\eta = \frac{2}{1+\sqrt{1+(2mb)^2}}$
Optimum profile area	$A_p = \frac{0.500}{h^2k}\left(\frac{q_o}{\theta_o}\right)^3$	$A_p = \frac{0.347}{h^2k}\left(\frac{q_o}{\theta_o}\right)^3$	$A_p = \frac{0.327}{h^2k}\left(\frac{q_o}{\theta_o}\right)^3$
Optimum height & thickness for given A_p	$b = 1.262\left(\frac{kA_p}{2h}\right)^{1/3}$ $\delta = 0.791\left(\frac{2hA_p^2}{k}\right)^{1/3}$	$b = 1.506\left(\frac{kA_p}{2h}\right)^{1/3}$ $\delta = 1.328\left(\frac{2hA_p^2}{k}\right)^{1/3}$	$b = 1.262\left(\frac{kA_p}{2h}\right)^{1/3}$ $\delta = 0.791\left(\frac{2hA_p^2}{k}\right)^{1/3}$

Table II: Fin Design Method

REQUIRED
$T_s = 347$ deg F
GIVEN
$b = 0.0364$ ft
$d_i = 0.125$ ft
$d_o = 0.208$ ft
$k = 225$ btu/ft-hr-deg F (copper fins)
$L = 0.5$ ft
$T_1 = 80$ deg F
$W = 96$ pph
$\delta = 0.0026$ ft



Parameter or Property	Procedure	First Trial	Second Trial	Third Trial	Fourth Trial	Fifth Trial
n	assume	24	32	40	48	56
A	$A = \frac{\pi}{4}(d_o^2 - d_i^2) - n\delta b$	0.0195	0.0187	0.0180	0.0172	0.0165
P	$P = \pi d_i + 2nb$	2.14	2.72	3.31	3.89	4.40
d_e	$d_e = 4A/P$	0.0364	0.0275	0.0218	0.0177	0.015
ΔT	$\Delta T = \frac{q}{WC_p}$	44	44	44	44	44
T_1	given	80	80	80	80	80
T_2	$T_2 = T_1 + \Delta T$	124	124	124	124	124
T_A	$T_A = T_1 + \Delta T/2$	102	102	102	102	102
T_s	required	347	347	347	347	347
T_m	$T_m = \frac{T_s + T_A}{2}$	225	225	225	225	225
$kP_r^{1/3}$ @ T_m	from Figure 2	0.0161	0.0161	0.0161	0.0161	0.0161
μ @ T_m	from Figure 2	0.0515	0.0515	0.0515	0.0515	0.0515
G	$G = \rho V = W/A$	4820	5130	5330	5580	5820
R_e	$R_e = Gd_e/\mu$	3400	2740	2260	1915	1695
j	from Figure 6	11.2	7.8	5.3	4.45	4.3
h	$h = j/d_e\,{}^{kPr\ 1/3}$	4.95	4.57	3.91	4.04	4.62
m	$m = \sqrt{\frac{2h}{k\delta}}$	4.10	3.94	3.64	3.70	3.96
mb	compute	0.15	0.144	0.133	0.135	0.144
η	from Figure 5	0.992	0.993	0.994	0.994	0.993
S_f	$S_f = 2nbL$	0.437	0.582	0.729	0.874	0.984
nS_f	compute	0.433	0.577	0.723	0.868	0.977
S_b	$S_b = (\pi d_i - n\delta)L + \frac{\pi}{4}d_i^2$	0.095	0.090	0.084	0.079	0.077
S_T	$S_T = S_b + nS_f$	0.528	0.667	0.807	0.947	1.054
ζ	$\zeta = \frac{hS_T}{WC_p}$	0.113	0.1316	0.1362	0.1651	0.2104
$F = e^{\zeta}$	from log table or slide rule	1.1198	1.1405	1.1462	1.180	1.224
FT_2	compute	139	141	142	146	152
T_1	given	80	80	80	80	80
$FT_2 - T_1$	compute	59	61	62	66	72
$F - 1$	compute	0.1198	0.1405	0.1462	0.180	0.224
T_s	$T_s = \frac{FT_2 - T_1}{F - 1}$	494	435	423	367	321
						O.K.

NOTE: The number of fins is strictly up to the designer. The number of fins in the cross-section above does not indicate a requirement but was chosen merely for convenience in drawing.

The design of a transistor cooler like the one in *Figure 7* is simple. As many fins in the form of pins as there is room for are arranged and spaced in a more or less regular geometric pattern. For a given coolant quantity and temperature, a heat transfer correlation such as Colbun's yields the heat transfer coefficient:

$$hd/k = 0.33(\rho Vd/\mu)^{0.6}(C_p\mu/k)^{0.33}.$$

Base and pin areas (the latter adjusted for pin efficiency) are then inserted to get the base-surface, or case, operating temperature. This type of auxiliary cooling surface is light, offers an exceptionally high surface area per unit volume, and meets all military requirements for lightweight airborne equipment.

Case 3: Air-Cooled Vacuum-Tube Amplifier

Vacuum-tube amplifiers requiring cooling can be mounted on, and made an integral part of, a force-cooled electronic chassis cold plate. This is good for cooling but not for maintenance—whenever a defective amplifier has to be replaced, so does the entire cold plate.

Alternatively, the tubes can be mounted on a metal plate, that in turn is secured to a fiberglass or epoxy baseboard (*Fig. 8*). The baseboard has the wiring, auxiliary circuits, and components as well as a connector. The amplifier is installed by plugging the baseboard connector into the chassis.

Before we can design our cooling system, we must computate the average tube temperature. For example, assume that the amplifier mounting has the dimensions shown in *Figure 8*, that each tube has a diameter of 0.468 in. (including shield), a length of 1.35 in., a negligible temperature drop through the shield, and dissipates 3.18 W, and that 0.5 ppm of air at 110 deg F enters the channel. First we calculate the necessary physical parameters—flow area and perimeter and area of the heat transfer surface:

$$A = \frac{3.25 \times 1.00 - 3(\pi/4)0.468^2}{144} = 0.0190 \text{ sq ft},$$

$$P = \frac{3\pi \times 0.468 + 3}{12} = 0.618 \text{ ft},$$

$$S = \frac{3\pi \times 0.468 \times 1.35 + 3 \times 2(\pi/4)0.468^2 + 3 \times 3}{144} = 0.111 \text{ sq ft}.$$

From these we get the equivalent diameter:

$$d_e = 4A/P = (4 \times 0.0190)/0.618 = 0.123 \text{ ft}.$$

The air temperature rise is:

$$\Delta T = \frac{q}{WC_p} = \frac{3 \times 3.8 \times 3.413}{0.5 \times 60 \times 0.241} = 4.5 \text{ deg F}.$$

Therefore, the outlet air temperature is:

$$T_2 = T_1 + \Delta T = 110 + 4.5 = 114.5 \text{ deg F}.$$

Next we find the average air temperature:

$$T_A = T_1 + \Delta T/2 = 110 + 2.25 \approx 112 \text{ deg F}.$$

For this value, *Figure 2* gives $\mu = 0.0451$ lb/hr-ft and $k = 0.0159$ btu/ft-hr-deg F, so that we get:

$$C_p\mu/k = 0.685, \qquad (C_p\mu/k)^{0.33} = 0.882.$$

On the basis of these properties, we can evaluate the heat transfer coefficient. The mass air flow and the Reynolds number are:

$$G = \rho V = W/A = 30/0.0190 = 1580 \text{ lb/sq ft-hr},$$

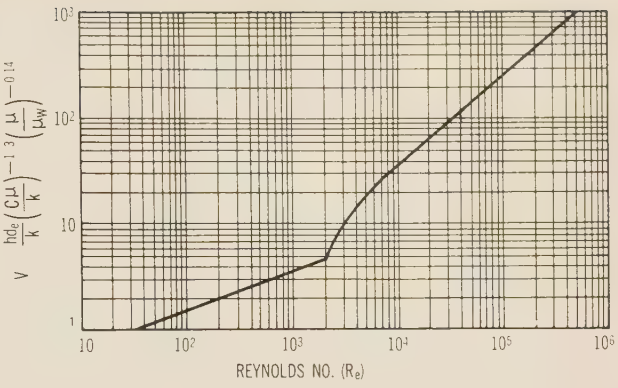


FIGURE 6: Heat transfer from a longitudinal fin, where $h = j(k/d_e)(C_p\mu/k)^{1/3}(\mu/\mu_w)^{0.14}$.

$$R_e = \rho Vd_e/\mu = (1580 \times 0.123)/0.0451 = 4300.$$

Goldberg's correlation gives:

$$h = 12.53GC_pR_e^{-0.81}(C_p\mu/k)^{0.33},$$

assuming all thermal properties are, as in our case, evaluated at the average coolant temperature. Therefore we get:

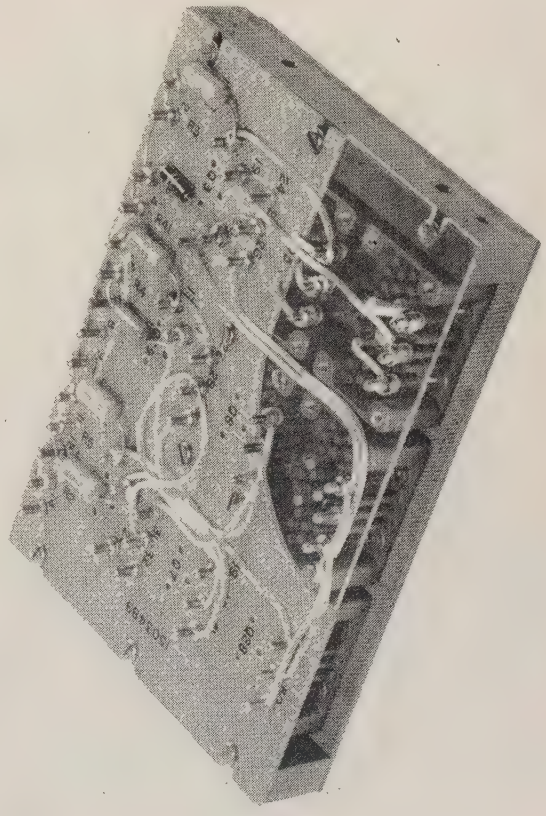


FIGURE 7: Typical arrangement of pin, or spine, fins (for which a Sperry patent is pending) used to cool power transistors. The results with many configurations like this one substantially agree with the Colbun correlation.

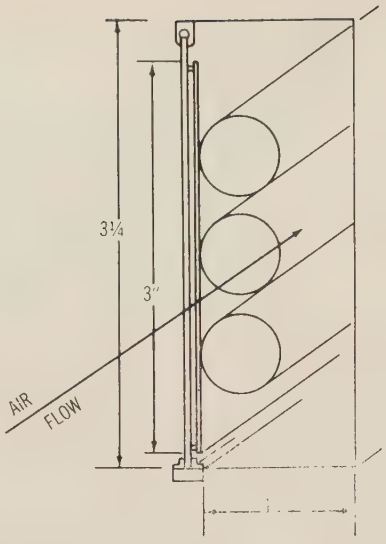


FIGURE 8: Recommended mounting method for force-cooled vacuum-tube amplifiers.

$$h = 12.53 \times 1580 \times 0.241 \times 4300^{-0.81} \times 0.882 = 4.77 \text{ btu/sq ft-hr-deg F.}$$

The temperature differential between tube and coolant stream and the average bulb temperature then are:

$$\Delta T = \frac{q}{hS} = \frac{3 \times 3.18 \times 3.413}{4.77 \times 0.111} = 62.5 \text{ deg F,}$$

$$T_B = T_A + \Delta T = 112 + 62.5 = 174.5 \text{ deg F.}$$

Case 4: Evaporation-Condensation Cooling

Because of their volatility, fluorochemicals and certain other liquids can remove large amounts of heat and so help the designer anxious to miniaturize electric and electronic equipment. Fluorochemical liquids, though, necessarily impose a weight penalty and heavy, inert fluorochemical vapors therefore have been proposed in their place. Recently, a combination of liquid and vapor has been used for cooling a high-voltage power supply—a fluorochemical is used as a boiling liquid and also as heavy, inert vapor in the space above the liquid (*Fig. 9*).

The power supply has all its heat-generating and high-voltage components contained within a pressure vessel and dissipates 1600 W. The vessel has a total inside height of eight inches and is filled with about three inches of the fluorochemical liquid and five inches of the fluorochemical vapor. All high-heat-dissipating components are placed below the level of the liquid, which thus is made to boil as energetically as possible. The heavy, inert vapor provides the dielectric medium for the components placed above the liquid, which dissipate little or no heat.

Heat is transferred by nucleate boiling of the liquid at the submerged component surfaces and forced diffusion of the resultant vapor through the inert gas. The hot vapor condenses on the underside of the cover, which acts as a cold plate. The droplets of condensate come full cycle as they drip back into the pool of liquid. The heat absorbed by the cover in condensing the vapor is carried away by forced convection to a liquid coolant circulating within it. The importance of the inert vapor lies in the fact that the boiled-off liquid passes from the liquid surface to the condensing surface by diffusion though the vapor, which aids the cooling process.

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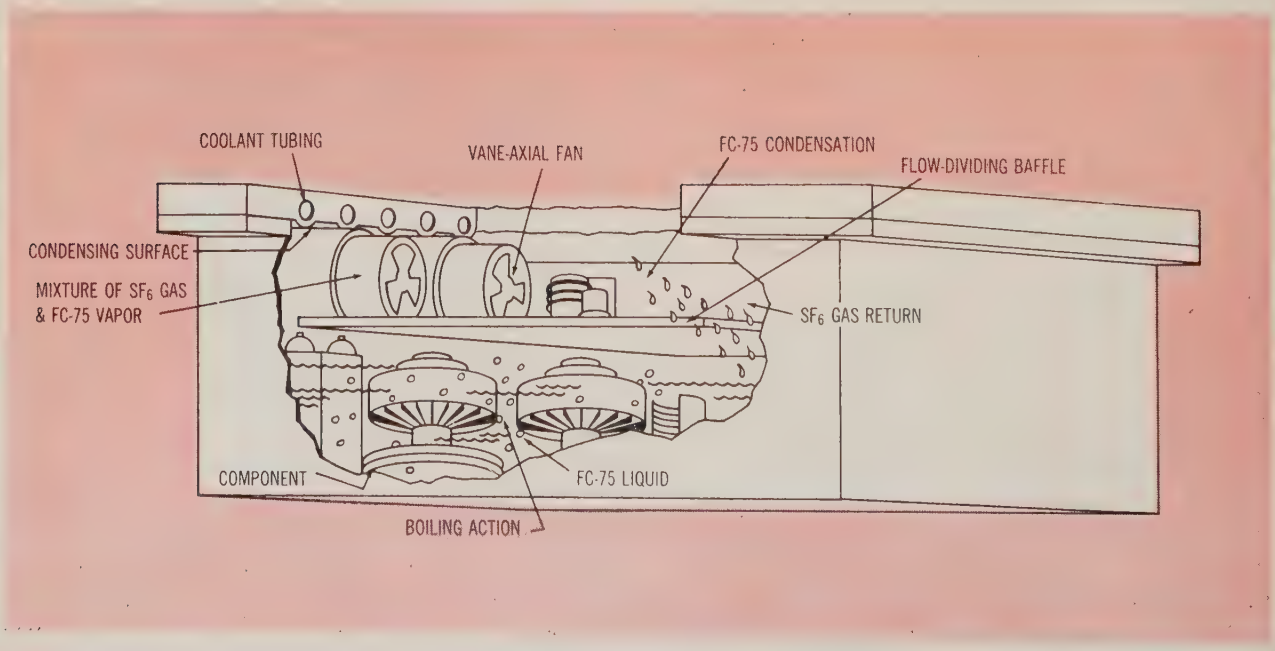
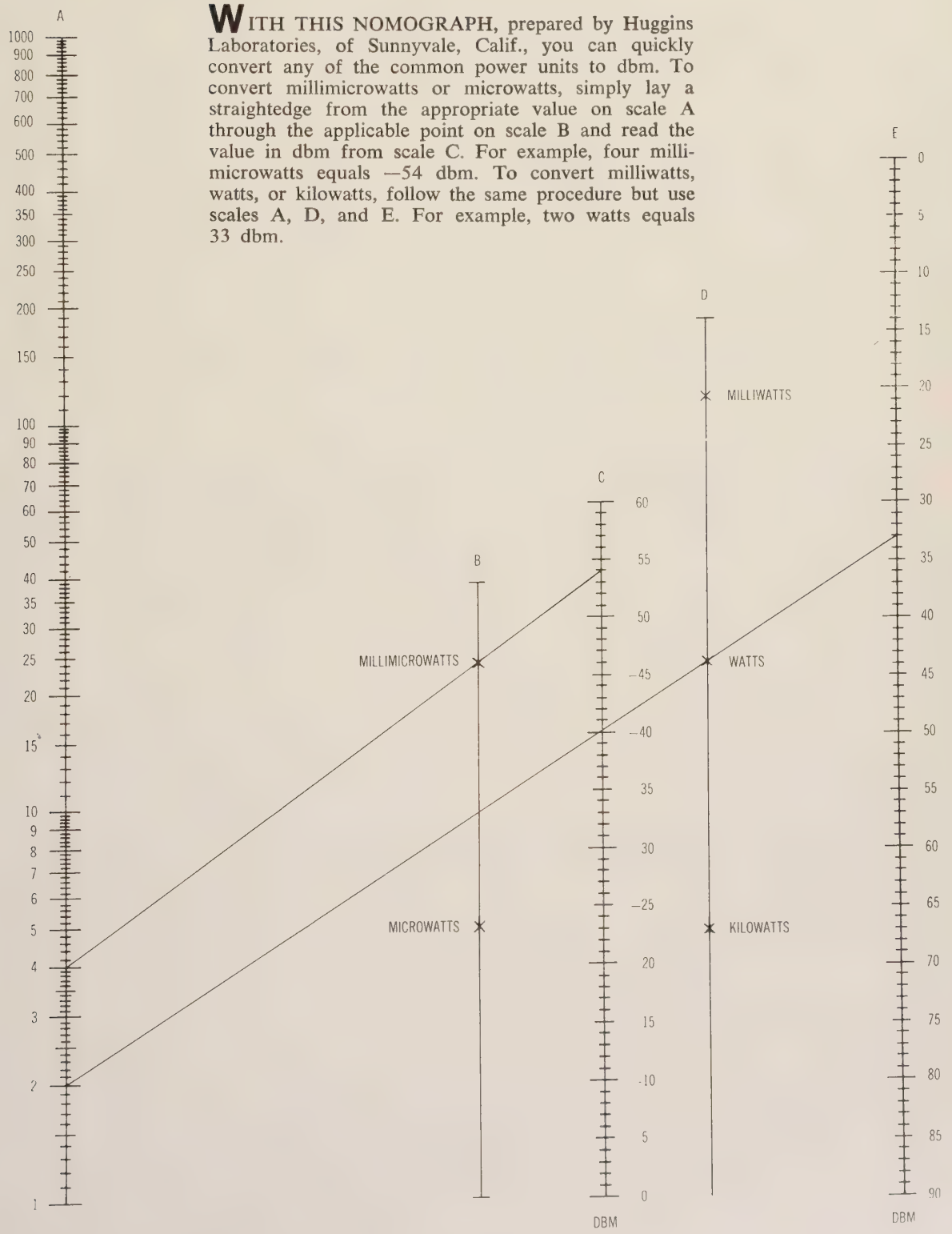


FIGURE 9: Evaporation-condensation cooling system for a high-voltage power supply. The force-draft vane-axial fans mounted above the liquid improve the system performance by accelerating the diffusion of the boiled-off liquid and also provide condensation by forcing vapor into contact with the condensating surface.

Power unit conversion

WITH THIS NOMOGRAPH, prepared by Huggins Laboratories, of Sunnyvale, Calif., you can quickly convert any of the common power units to dbm. To convert millimicrowatts or microwatts, simply lay a straightedge from the appropriate value on scale A through the applicable point on scale B and read the value in dbm from scale C. For example, four millimicrowatts equals —54 dbm. To convert milliwatts, watts, or kilowatts, follow the same procedure but use scales A, D, and E. For example, two watts equals 33 dbm.



by H. K. Jenny, Manager, Microwave Engineering, Electron Tube Div., Radio Corp. of America*

Traveling-wave tubes

extend microwave power

MICROWAVE RECEIVERS require low-noise input amplifiers for high sensitivity and long-range reception with minimum transmitter output. Devices like masers and parametric amplifiers provide very low noise figures over narrow frequency ranges, but among wideband low-noise microwave devices the traveling wave tube (TWT) heads the list. Conventional microwave tubes, which combine circuit and tube elements in one envelope, usually can be tuned over frequency

* Electron Tube Div., Radio Corp. of American, Harrison, N. J. The author wishes to acknowledge the support of the Navy for a large part of RCA's work on electrostatically focused high-power TWTs.

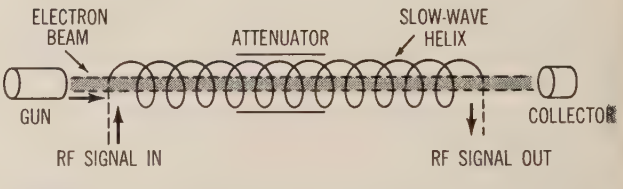
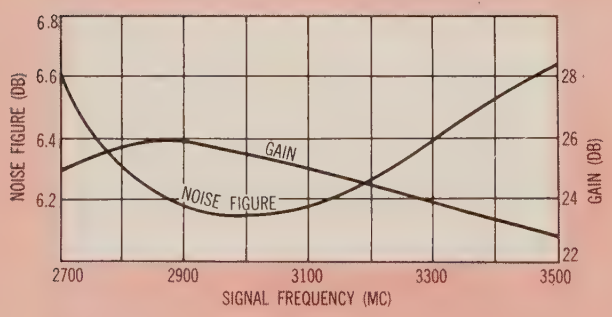
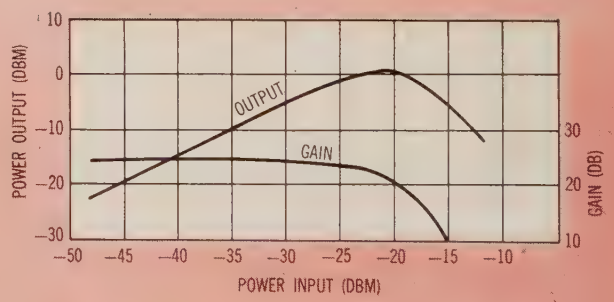


FIGURE 1: Basic elements of a traveling-wave tube. The electromagnetic wave travels from left to right along the helix.





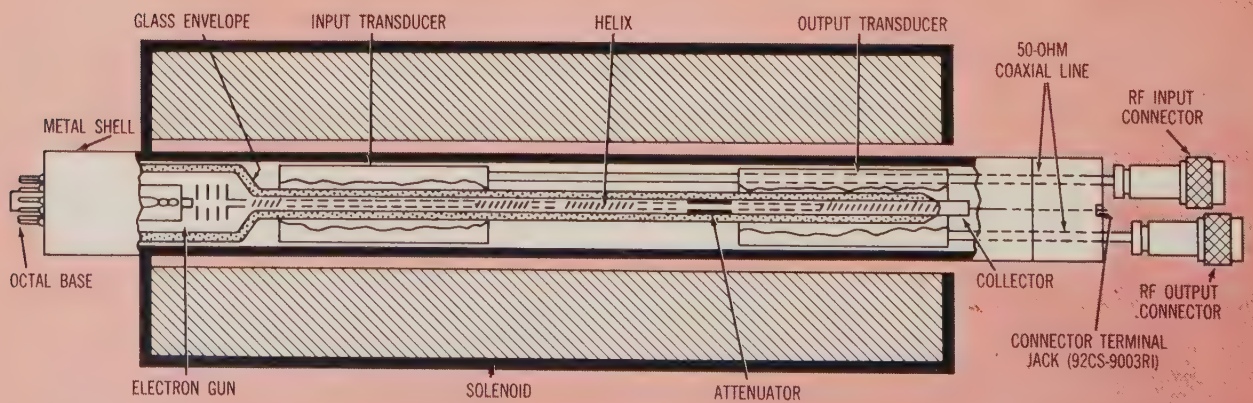


FIGURE 2: RCA Type 6861 low-noise TWT and its performance under optimum low-noise conditions.

IN BRIEF

In the last few years, the TWT's great theoretical promise for amplification, oscillation, mixing, and many other functions in the microwave region has begun to be fulfilled as practical low-noise microwave amplifiers, permanent-magnet-focused medium-power amplifiers, and electrostatically focused high-power tubes suitable for up to more than 9000 mc have become available. With noise figures of 4-6 db or even lower, the modern TWT is a match for the parametric amplifier. Its prime advantage is its broad bandwidth of an octave or more.

Permanent-magnet-focusing structures have simplified these tubes and made them considerably lighter. Gains of more than 50 db and operation over a frequency range of several octaves are close at hand.

The electrostatically focused tube has substantial advantages in size and weight. Its performance at 9000 mc indicates that it will not only replace the more conventional TWTs but also meet demands that cannot be met now.

ranges of several per cent. The TWT can operate over bandwidths of more than an octave. Moreover, it can be used as an amplifier, oscillator, mixer, frequency multiplier, frequency shifter, noise generator, limiter, phase shifter, and detector.

The main element of the TWT is a helical slow-wave structure that slows down the propagation of the microwave signal in the axial direction, providing an efficient exchange of energy between a traveling wave and electron beam emerging from an electron gun (*Fig. 1*). The beam is held inside the helix structure by an axial magnetic field that extends the full length of the slow-wave structure. Energy is exchanged when the signal propagating velocity is equal or close to the velocity of the electrons in the beam.

Signal modulates beam velocity

The input signal reaching the helix modulates the velocity of the beam. As the electrons travel along the helix, this velocity modulation is transformed into a density modulation. Energy is then coupled back into the helix and leaves the tube through the output circuit as an amplified signal. An attenuator on the helix prevents circuit feedback from output to input.

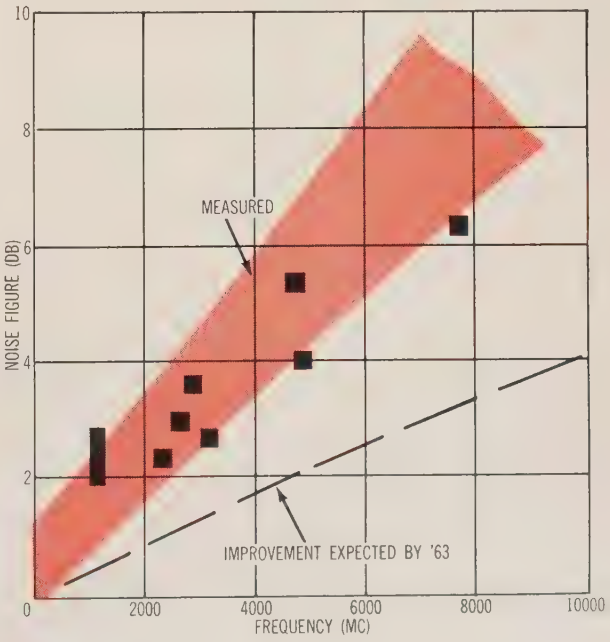
In the early fifties, scientists at Bell Telephone Labs, RCA, and Stanford U. discovered noise in electron beams in standing-wave patterns that could be altered by changing the beam velocity. By designing a special gun based on this phenomenon and by repositioning the helix entrance to coincide with a minimum point of the stand wave, a noise figure on the order of nine decibels was obtainable. This noise figure is substantially better than the 20-30 db of the conventional low-power TWT.

Our Type 6861 TWT with a noise figure of 5-7 db is the result of continued design refinement based on the special electron gun (*Fig. 2*). This tube has excellent long life—more than 19,800 hours of satisfactory operation as a preamplifier has been reported for radar application and over 30,000 hours in radio telescopes.

Several basic design considerations besides noise reduction apply for the low-noise TWT:

- The cathode must have a very thick, dense, and uniform emissive coating, and must be able to operate at low temperatures.
- Extreme care and cleanliness are required in tube assembly and processing.
- Careful gun design is essential if you want to get a clean, hollow electron beam and the proper voltage gradient along the gun.
- Losses at the input coupler and the helix add directly to the noise figure and must be kept to a minimum.
- A high gain per unit length keeps the helix losses low.
- Because current interception reduces gain and increases noise, the beam must be well focused.

FIGURE 3: Measured and predicted noise figures of TWTs.



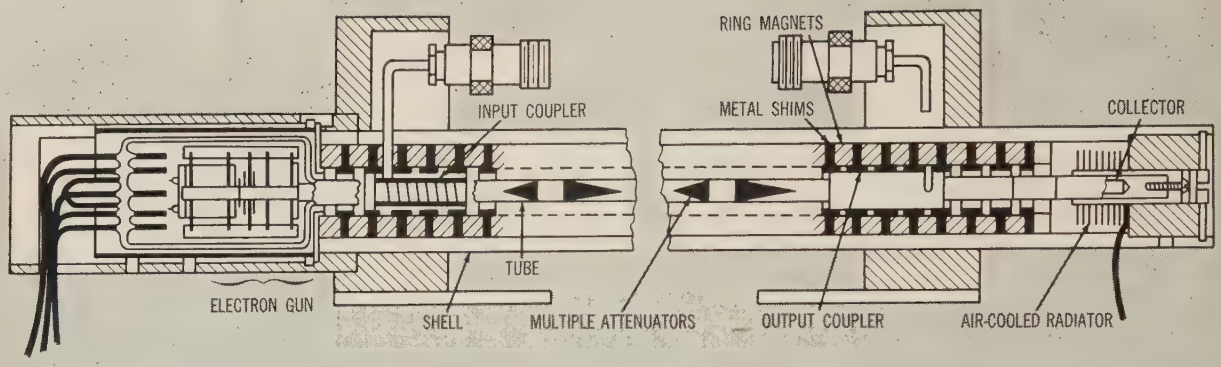


FIGURE 4: RCA's Type 4009 is a typical periodic-permanent-magnet TWT.

Though current commercial tubes have noise figures of 4-6 db, lab measurements have already been made at 2.5 db, and theoretical studies point to even lower values (*Fig. 3*). The TWT therefore must be considered comparable to parametric amplifiers for microwave receiver applications. Where wide bandwith is required, they are actually preferred.

The first attempts to design a medium-power TWT resulted in a fragile, thermometer-like device operating inside a heavy solenoid that required hundreds of watts to energize. By now, focused medium-power TWTs are available in a broad line of compact assemblies that are much easier to use (*Fig. 4*).

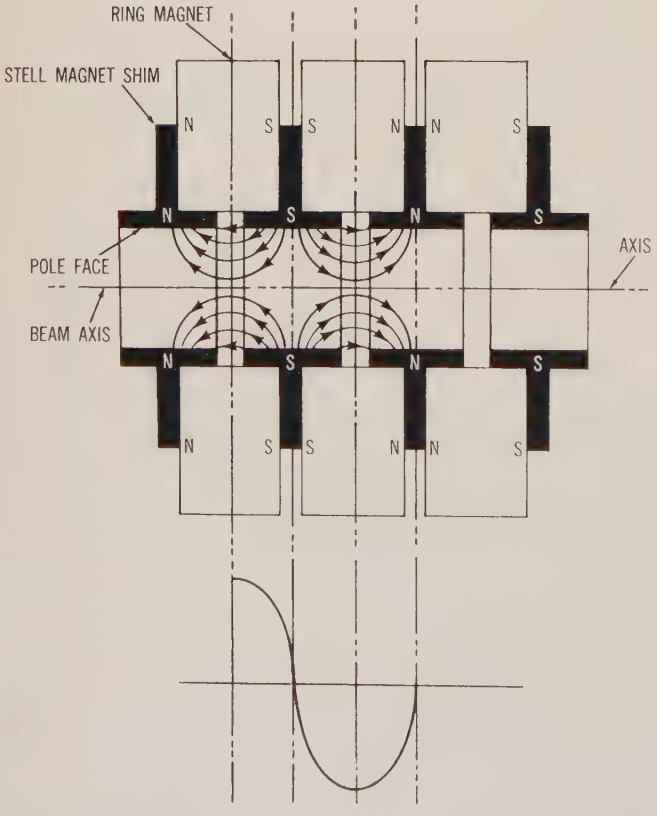


FIGURE 5: Focusing structure—with ring magnets and steel shims—used in periodic-permanent-magnet TWTs.

The several hundred gauss required for the magnetic field is provided by a series of magnetic lenses which replaces the long, uniform field of the solenoid. (*Fig. 5*) The beam is focused by a series of axially polarized ferrite ring magnets and steel pole pieces stacked alternately to achieve a magnetic field with approximately a sine-wave configuration. When a parallel-flow beam passes through these magnets, it is strongly constrained in the areas of maximum flux and weakly constrained in the areas of minimum flux. Although the resultant spiraling motion of the individual electrons causes beam-widening, a performance equivalent to that of a tube with a uniform field can be obtained by careful design.

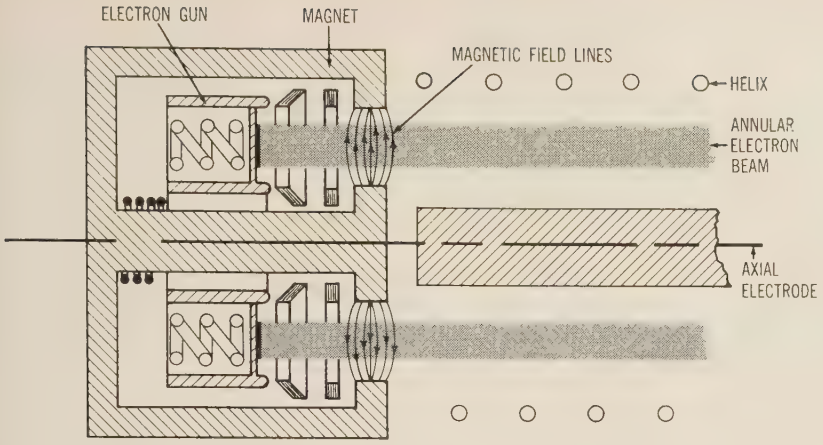
Most of the presently available periodic-magnetic-focused TWTs operate over a frequency range of 2:1 or more. These durable devices have an operating life of many thousands of hours and can withstand 5-10 g vibration at 5-2000 cps (with shocks of 30 g), ambient temperature of —65 to 100 deg C, 50,000 ft altitude, and 100 per cent humidity.

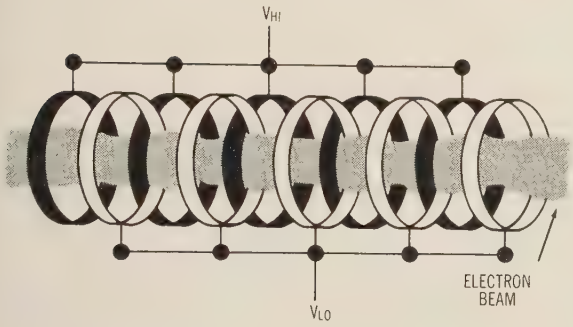
Full potential not yet realized

Extensive data are available on the performance of these tubes as amplifiers, oscillators, mixers, limiters, frequency multipliers, and shifters, as well as on the tandem operation of several tubes*. However these tubes have not yet reached their full potential, partly because many of them have been designed strictly to meet highly specific requirements. (Radio-relay links, for instance, require high linearity, good match, and low gain variations over relatively narrow bandwidths, as well as low spurious noise. Other applications require wide frequency coverage, flat power output, or a shaped gain curve.)

The "estiatron" is a new high-power TWT that uses electrostatic fields instead of magnetic fields. In the form of a double-helix TWT, it has a performance

* C. Cuccia, "RCA Periodically Focused Traveling-Wave Tubes"; RCA Tube, '59.





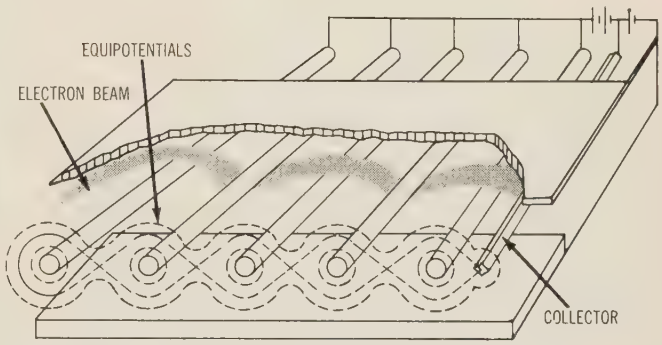


FIGURE 6: "Harris-flow"-focusing of an annular beam (left), electrostatic focusing of a beam flowing through a series of rings held alternately at high and low potentials (bottom left), and "slalom"-focusing (bottom right) have been evaluated for estiatrons.

equivalent to that of magnetically focused tubes.

Three methods of electrostatic focusing have been evaluated (*Fig. 6*):

- In "Harris-flow" focusing, a magnetic field in the gun region causes an annular beam to rotate. The centrifugal force of the rotating electrons is balanced by a strong radial electrostatic field between the helix and a positive axial electrode.
- A series of electrostatic lenses can be formed by rings or disks at alternate high- and low-voltage potentials. Near the low-voltage electrode, the electrons move slowly towards the tube axis; near the high-voltage electrode they move faster and away from the axis. However, the electrons spend more time in the part of the field pushing them towards the axis. The overall result therefore is an inward movement, which balances the space-charge forces that tend to spread the beam.
- "Slalom"-focusing is based on the fact that, among equipotential fields surrounding a parallel array of wires between two planes, there is only one pair of continuous equipotential surfaces that intersects between the wires. A ribbon beam launched in the right direction and with the right velocity follows this surface.

As the power output level of the electrostatic tube is increased (particularly at the higher frequencies) the helix becomes unsuitable as a slow-wave structure. A periodically loaded waveguide circuit can be substituted to produce a pulse amplifier putting out several kilowatts of power at 9000 mc.

The waveguide in this case basically is a high-pass filter that propagates energy with a phase velocity greater than the speed of light (at all frequencies). Loading the waveguide with periodically spaced obstacles causes reflections. The total reflection acts as a stop-band, transforming the high-pass filter into a bandpass filter. Coupling the capacities through circular (capacitative) slots produces a forward-wave interaction in which the phase and group velocity have the same sign; coupling with inductive (non-circular) slots produces a backward-wave interaction at the fundamental.

In the high-power TWT, the electrostatic lenses are formed by additional focusing electrodes inserted in the cavities so that they neither interact with the electric fields nor influence the propagating wave. These added electrodes are isolated from the structure to provide the two potential levels necessary for operation of the focusing lens. In practice, this isolation is accomplished by mounting the focusing electrodes on choke sections (*Fig. 7*). A number of these modules are stacked together to form the complete structure.

Figure 8 shows the ideal arrangement of electrodes for focusing a laminar, parallel-flow beam. The angle θ, which allows maximum beam transmission, increases with the ratio of beam diameter to focusing-electrode diameter.

Tube can operate in two modes

A theoretical analysis of this tube's operation shows that there can be two modes. When the cavity bars are operated at low voltage and the focusing electrodes at high voltage, the tube gain is higher than with comparable magnetic focusing, but this situation is reversed when the bars are operated at a high potential and the focusing electrodes at a low voltage. At 10,000 mc, this tube has developed several kilowatts of pulse power.

The Estiatron requires no higher voltages than do conventional TWTs operating with depressed collectors. It does, however, need a good deal more care in design and fabrication, because of the higher voltage difference

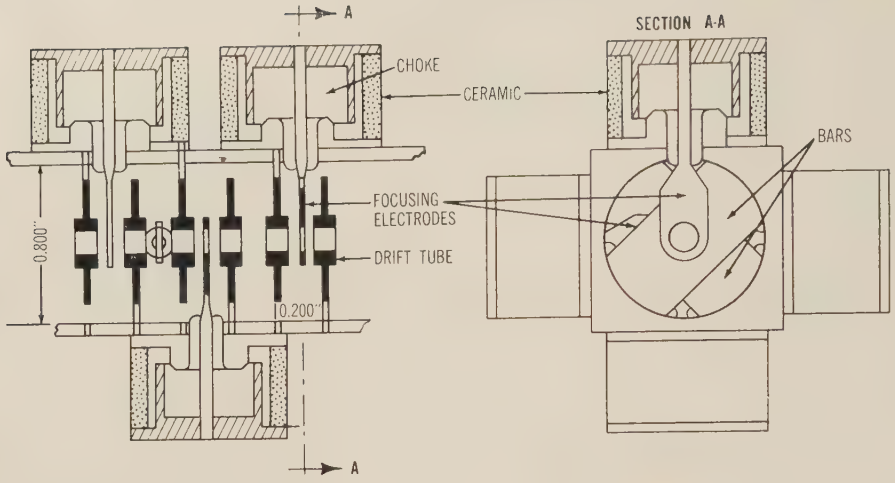


FIGURE 7: Crossed-bar structure with focusing electrodes supported by choke sections.

between adjacent circuit and focusing electrodes. Small and light helix-type Estiatrons are most suitable for the frequency range of 100-2000 mc. Several slow-wave structures are available for Estiatrons with megawatts of peak output power at these lower frequencies. With the periodically loaded waveguide, operation can be extended to the 9000-mc range (*Fig. 9*).

The Estiatron offers several advantages over other traveling-wave amplifiers:

- It is smaller and lighter and operates over wider ranges of temperature and vibration.
- It has a longer life, thanks to the absence of ion oscillations and of ionic bombardment of the cathode.
- Improved interaction between beam and circuit provides higher gain and power output, while depressed-collector operation gives higher efficiencies.

Operating experience on both low and high-power Estiatrons indicates that this type of tube can not only replace the more conventional TWTs but can also meet requirements that could not be met before.

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FIGURE 8: Electrostatically focused beam-type amplifier with ideal focusing electrodes (based on electrolytic tank measurements).

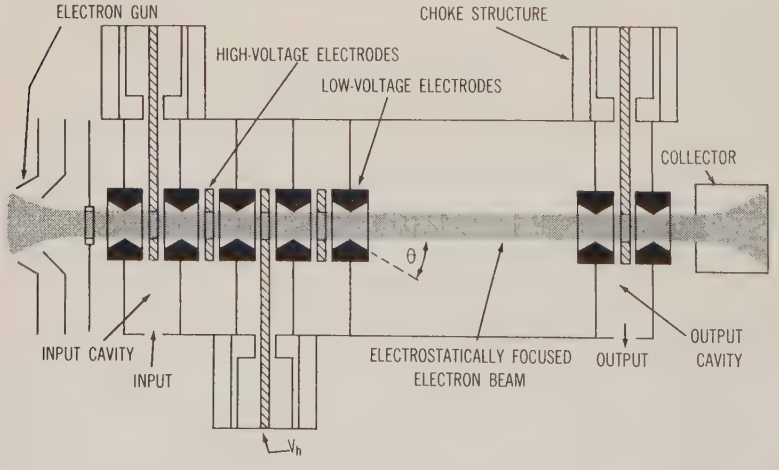
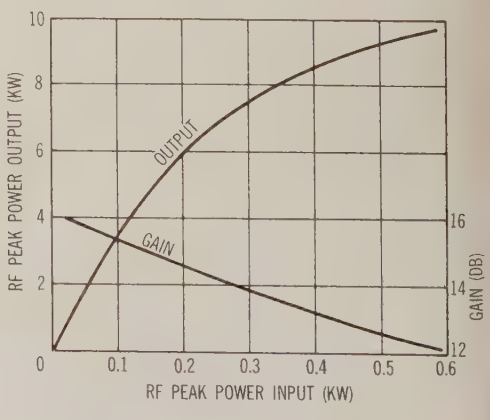


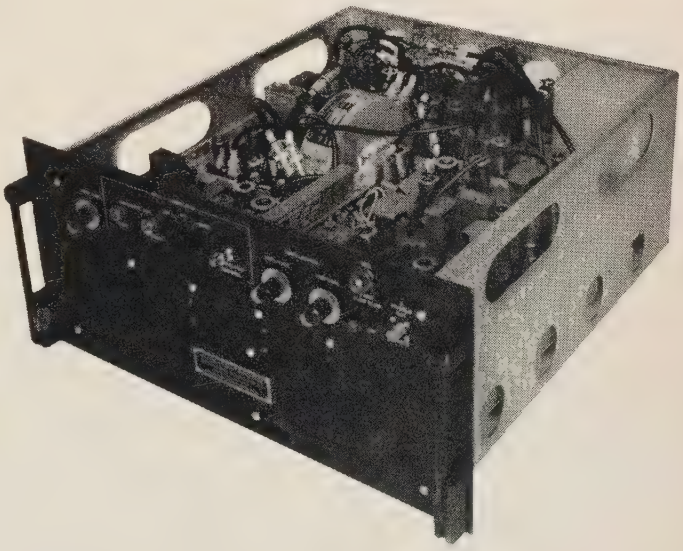
FIGURE 9: Peak RF power output and gain vs peak RF power input for electrostatically focused TWTs.



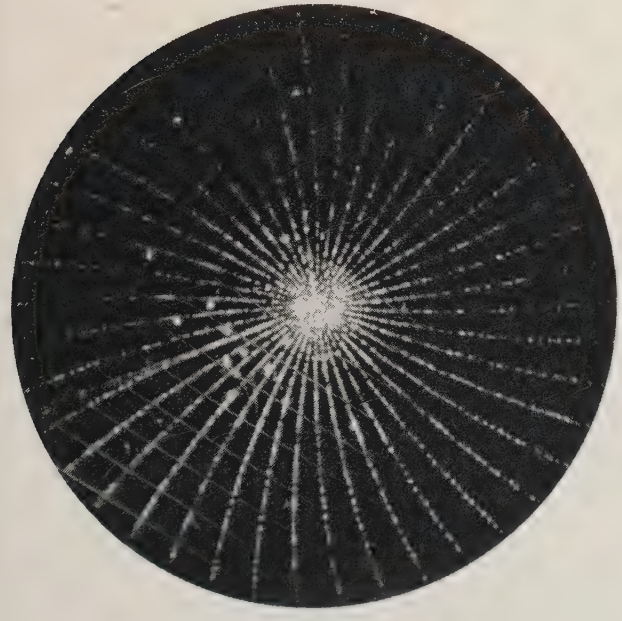
by **Bernard Kovit,** Associate Electronics Editor

Video correlator beats ECM and RFI

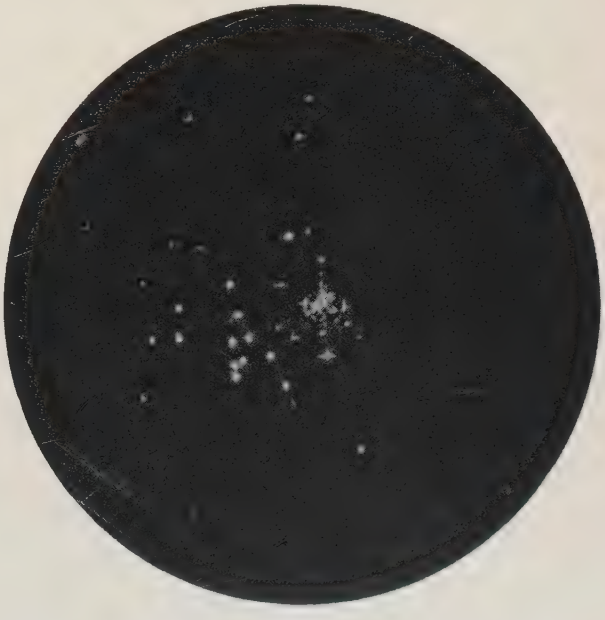
THE VIDEO correlator, invented by James H. Brown, of Temco Electronics Div., Ling-Temco-Vought Inc., Box 5003, Dallas 22, Texas, is a PRF-discriminating radar video processing system that minimizes the effects of noise, interference between radars, and PPI jamming signals. Basically, it consists of a video multiplier circuit with two inputs, one of which is the signal in a delay-line feedback loop tapped off the signal output. This signal is delayed by an interval corresponding to the interpulse time between successive arrivals of the desired, received signal pulse train. Signal enhancement is based on the repeated multiplication of radar return signals with the preceding delay-synchronized signals which prevents the buildup of noise and interference by non-coincident pulse trains. Temco's system reportedly provides improved discrimination against pulsed CW and FM interference and improves detection and lock-on performance by up to 30 per cent. USAF recently ordered video correlators for the Sage FPS-6 height finders. Other obvious applications of the Temco design are shipboard radars, ground and airborne tracking, and discrimination radar. Write in No. 74 on reader service card for more information.



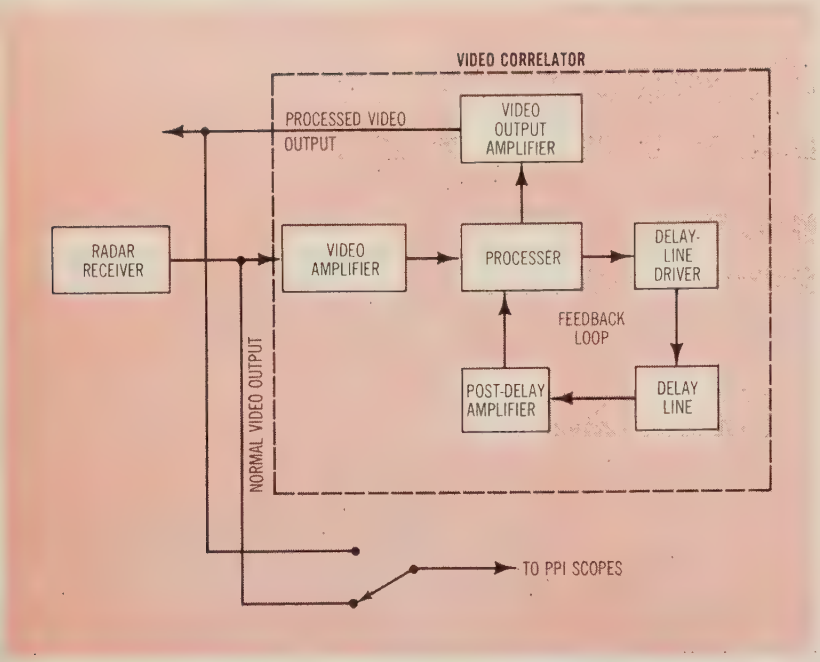
CORRELATOR can be designed to fit existing radar configurations, as does this unit for the AN/CPN-4 radar. It processes video in both normal and MTI modes and improves cancellation by as much as 32 db.



JAMMED



CLEARED

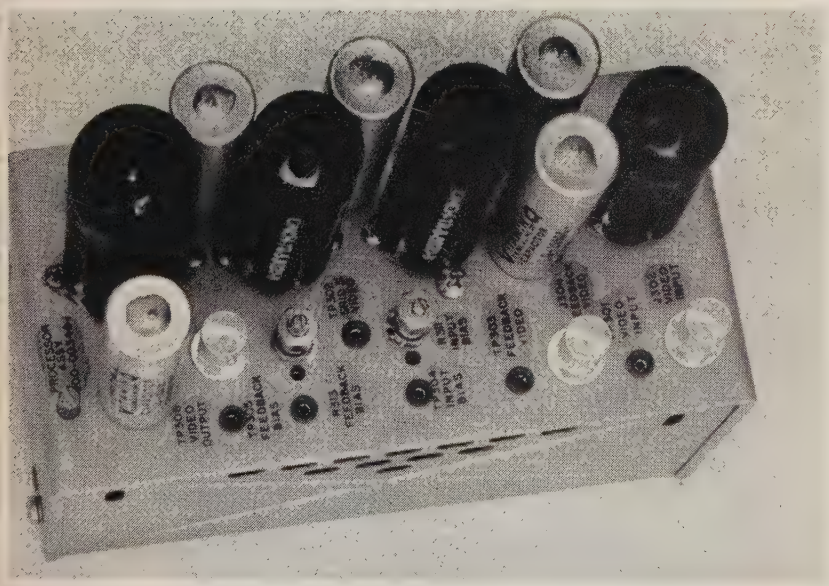


HOW IT WORKS: A pulse circulating in the delay-line loop returns to the multiplier in time with the next pulse of the pulse train. The delayed and input pulses are multiplied, and the product is again put into the delay line to await the next pulse. As the process is repeated, the signal grows in amplitude and, with a continuous pulse train, continues to build up until the loop is saturated. For noise alone or for a non-synchronous pulse train there's no such build-up. Being random, noise is not reinforced. Therefore, when the processed video output is applied to the radar, the synchronized true radar return signals are equal to or better than normal, while all undesirable signals and interference are depressed.

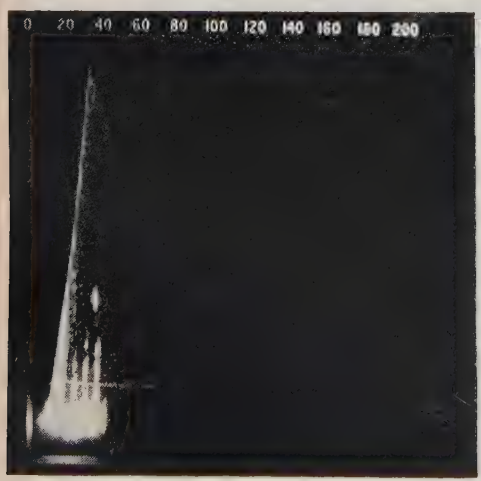
Comparative Test Data[1]

	Best	Worst
Linear processer	8.30 db	1.68 db
Blanking processer	5.88 db	0.00 db[2]
Video correlator	14.30 db	2.00 db

(1) Three operators made 20 runs each on normal and processed video. Receiver MDS was measured before and after each run. The data given represent the improvement at 0.5 blip-scan ratio. (2) At lower blip-scan ratios, the unit lowered the receiver sensitivity.



OUTPUT VIDEO MODULE shows the flexibility of Temco's design. It is part of an airborne version of the video correlator packaged in a separate chassis rather than integrated in the radar system as a modification kit.



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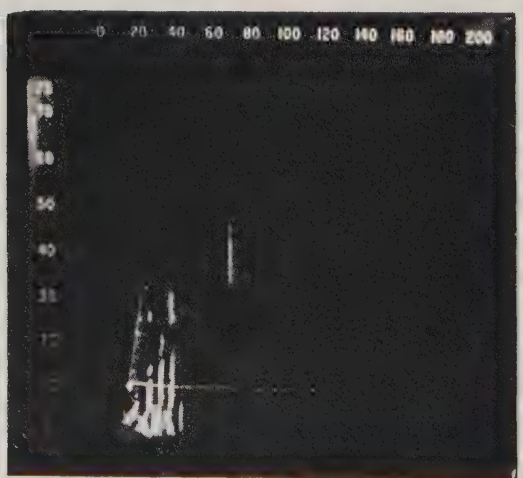

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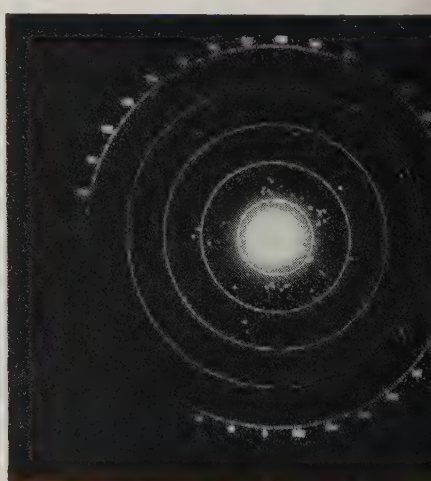

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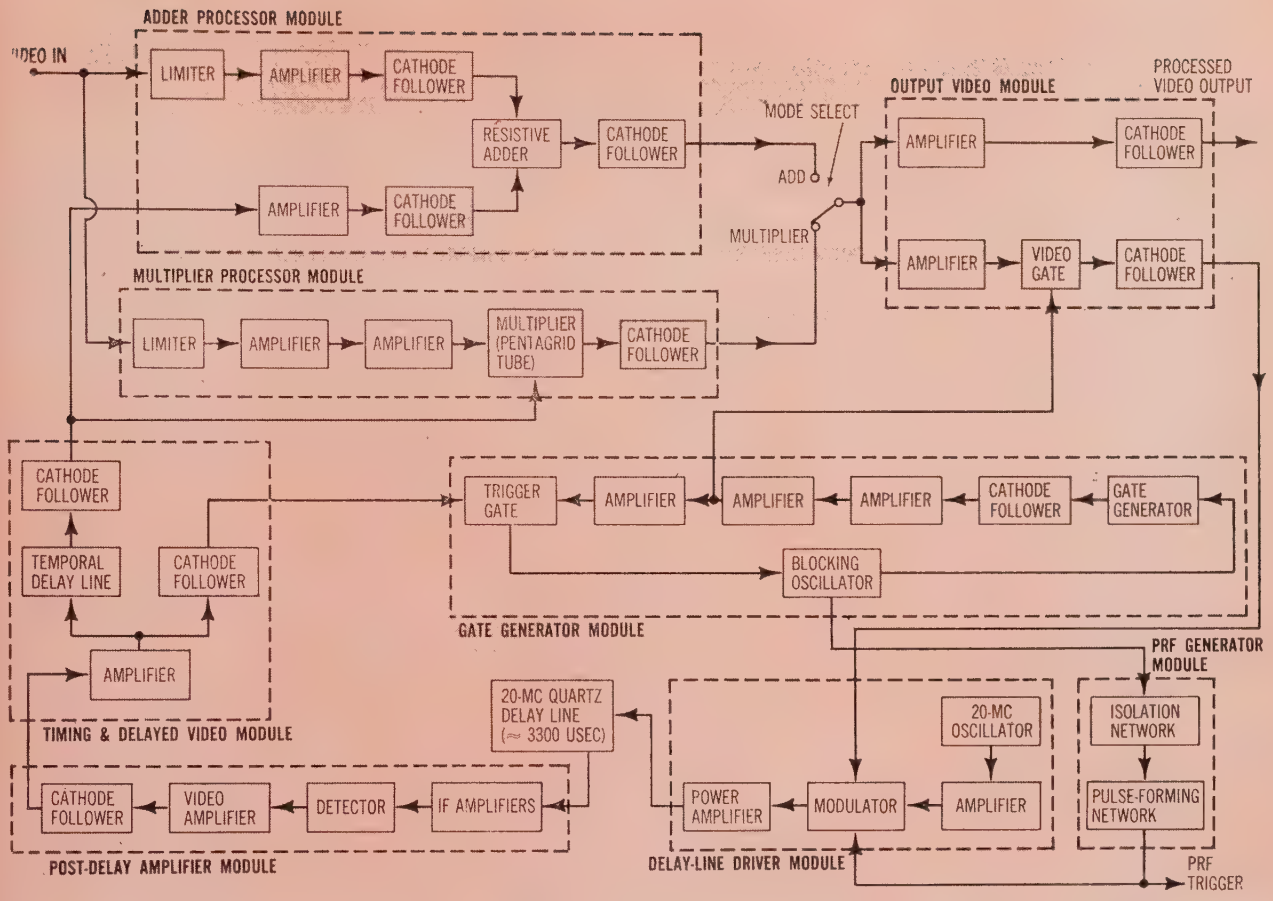
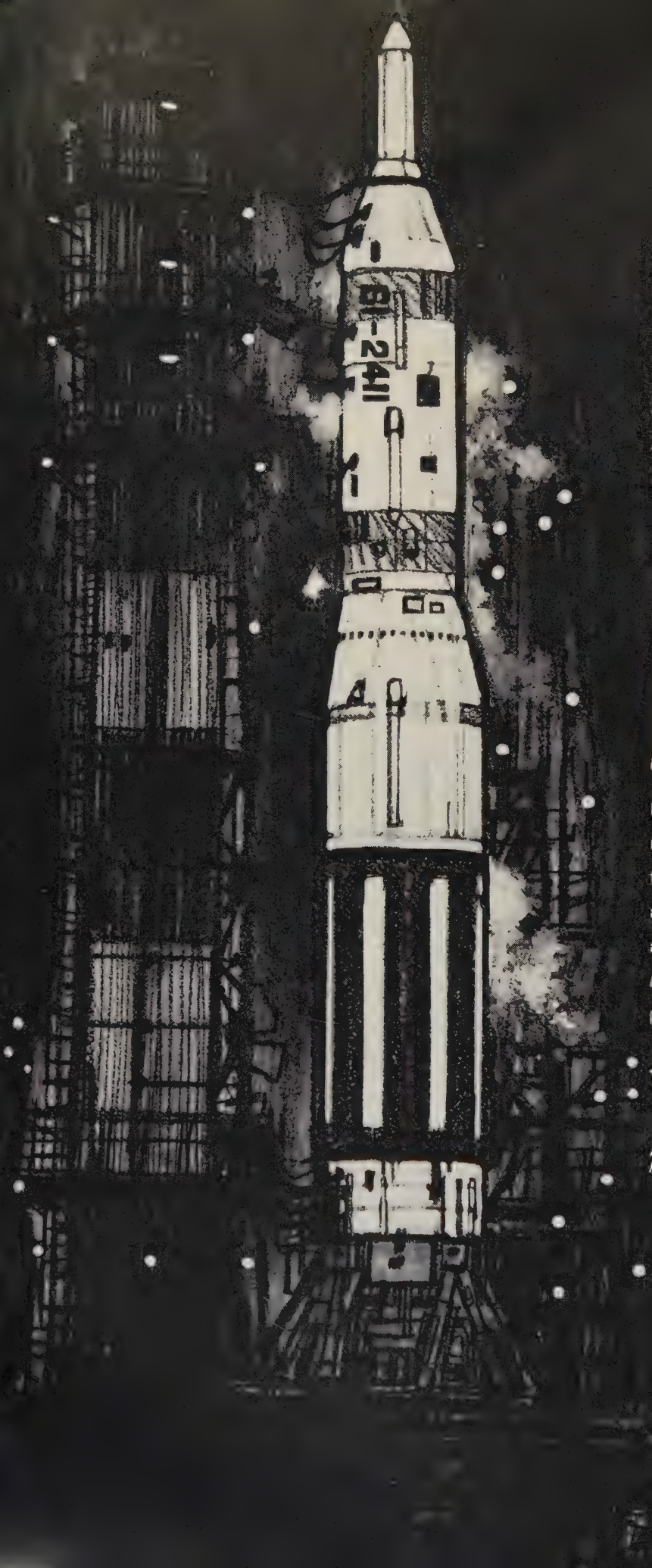


OVERALL SIGNAL FLOW of the video correlator at the modular circuit level. Temco has tried to modularize the system's circuits wherever possible for flexibility in form factor and packaging. Standard airborne packaging specs have been met. Both linear and non-linear video processing circuits have been packaged into standard modular units for 15-, 20-, and 30-cps quartz and magnetostrictive delay-line applications in several radar PRFs. Temco has also designed standard power-supply modules for correlators requiring 60 cps, 400 cps, or DC-DC power.

4

BEFORE AND AFTER—HRI scope photos (1 & 2) show the effects of high-level noise interference on the target information. Use of the video correlator clears the noise and enables the radar operation to keep an accurate track. PPI-scope photos (3 & 4) show how the video correlator helps you dig even previously hidden targets (circled) out of the noise in a cluttered display.



TAMING THE WILD BLUE YONDER

Primary responsibility for research, development, production, testing and evaluation of the Air Force's newest weapons systems—this is the mission of the recently created Air Force Systems Command. To its men—our defense architects—this mission presents the eternal challenge . . . that of taming the wild blue yonder.

AFSC

In pursuit of this challenge AFSC must call upon the vast resources of industry and of education, as well as those of the military. AC Spark Plug is being called upon to develop and produce the small, yet highly accurate inertial guidance system for the TITAN II. This is but one example of American industry and government working together as peoples of the world may live together—in peace.

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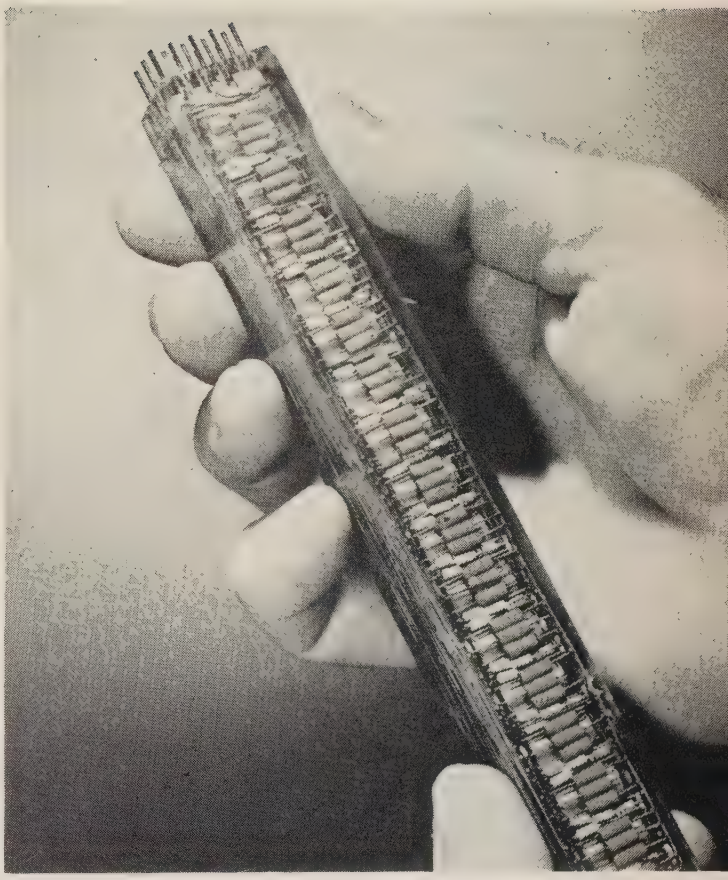
Welding for smaller, sturdier electronic packages

by J. R. Dow and E. J. Messner,
Materials & Process Engineer & Welding Engineer,
Aero-Weapons & Industrial Components Div.,
Raytheon Co.*

LIKE ALL modern airborne electronic equipment, the computers used in the Polaris ICBM had to be light, small, and reliable. To meet these requirements, we used spot welded interconnections between components packed in a "cordwood" arrangement to provide high packing density and structural rigidity.

Such a compact, log-piling assembly is possible because successive welds do not loosen those previously made, as would be the case with solder connections. Also, very short component leads can be used, since the

* Raytheon Co., Lexington, Mass.

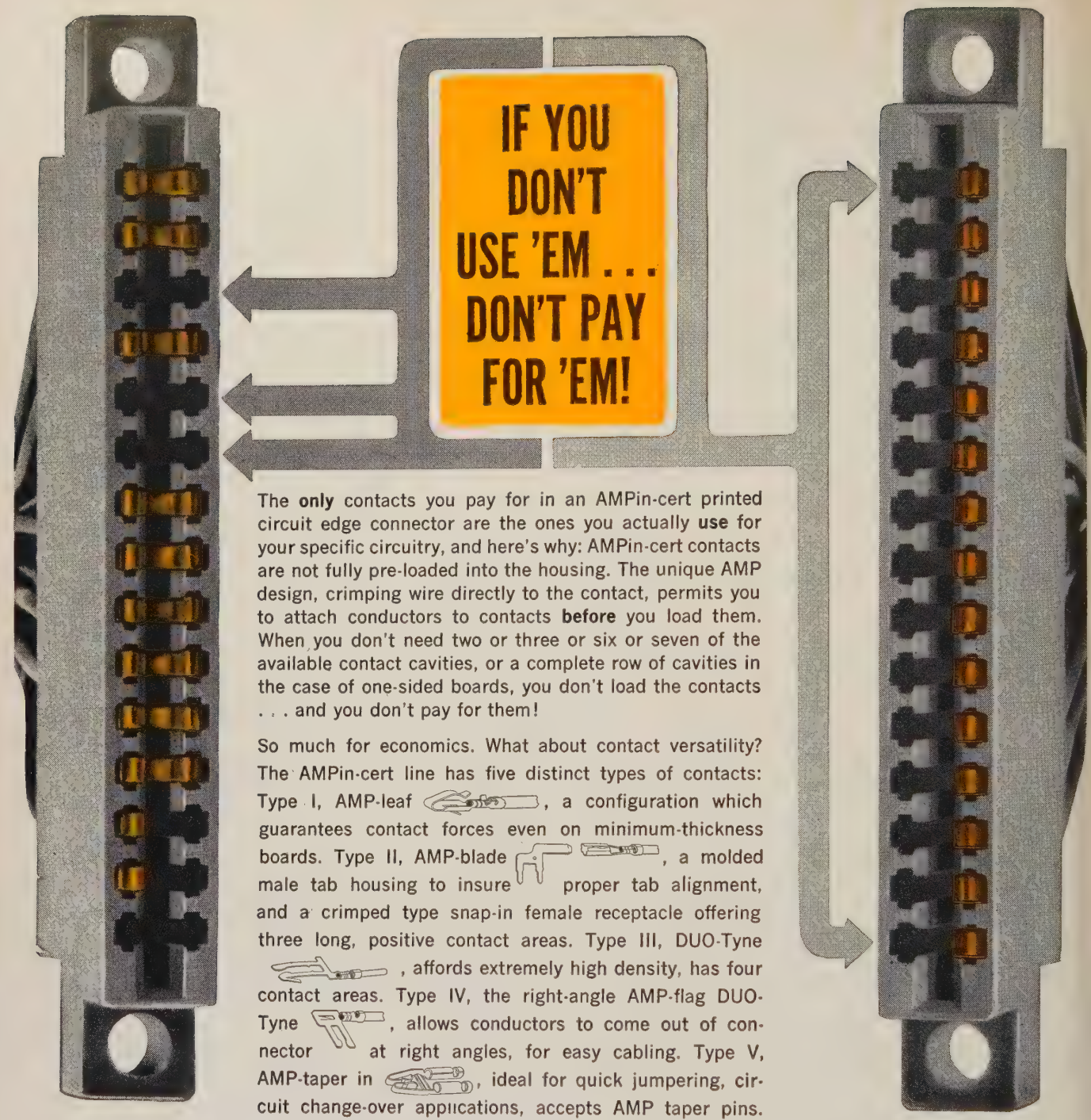


HIGH-DENSITY welded and potted package for the Polaris missile guidance computer. The use of this type of package reduced the weight of the missile's guidance system by 75 per cent from what it would have been otherwise.

IN BRIEF

High-resistance spot-welding of "cordwood"-stacked components is one of the newest joining techniques for small and reliable electronic packages. Cordwood-stacking of components is feasible because successive welds do not loosen those previously made. It also requires only very short component leads, since the low average heat involved in resistance-welding largely eliminates thermal damage to components. Weld-packing furthermore provides high stiffness-weight ratios, and subsequent embedding in plastic provides more than adequate module strength.

Since there are as yet no generally proven techniques for weld-packing, lead materials and electrode characteristics must be carefully considered and detailed records must be kept to provide production standards. Extensive checks of weld quality are also required.



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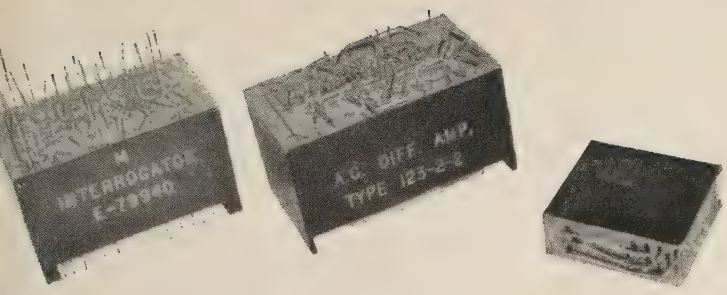


WELDED analog modules potted in anodized aluminum blocks for heat dissipation and easy mounting.

Component Lead Materials in Descending Order of Weldability

Nickel
Dumet
Gold-plated nickel-iron (42Ni-58Fe)
Advance
No. 52 Alloy (52Ni-48Fe)
Gold-plated Kovar
Tinned copper

high transient welding heat has a low average value so that the safe temperature rise within a component is not exceeded—a particularly important consideration for transistors and other semiconductors.

The high stiffness-weight ratio produced by weld-packing is further improved by embedding the assembly in plastic. The resulting module strength and toughness more than meets military environmental criteria.

Both DC-discharge and AC synchronous-timer welding machines are used. The DC welder is most advantageous when the materials to be joined are highly conductive and require a high peak current and very short discharge time. When a weld is made at a lower peak current but over a substantially longer time, the AC-timed equipment must be used. Ultrasonic welding looks promising for joining leads less than five mils in diameter without the application of heat.

Some leads difficult to weld

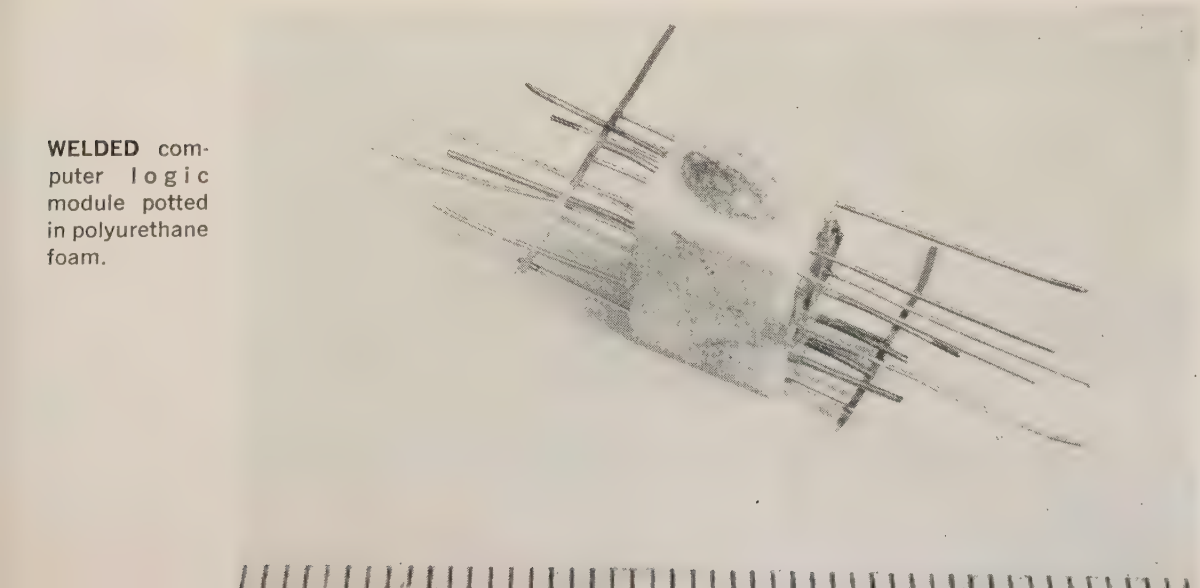
Not all component leads are equally easy to weld. Unfortunately, commercially available components usually have leads designed for soldering and their tin or lead coatings tend to make welding difficult. Most transistors and other semiconductors and components with hermetic glass seals use Kovar as their lead material, for which welding machine control and operation are fairly critical. Gold-plating of the Kovar leads makes welding much easier. As components leads generally are non-standard in material and often in coating, welds frequently must be made between dissimilar metals.

Each combination of lead materials requires a specific set of electrodes to provide the proper heat balance. This balance is a function of the volume of metal involved and its specific heat.

The condition of the welding electrode surface is important. Properly designed electrodes can give up to eight hours of welding before they must be polished. The electrode contact surfaces are contoured to shape and then polished on a cloth wheel impregnated with a suitable buffing agent. The electrode pressure must be high enough to eliminate the effect of surface oxides and non-uniform cross-sections of the welded parts, providing a small area of contact and preventing overheating the electrodes.

Welding operators must be carefully selected for dexterity and basic understanding of the welding process. Extensive training is required for optimum proficiency at spot-welding, and retraining may be necessary when an operator has not performed a particular weld for some time. An important part of the training requires the destructive testing of welds of all types to teach operators how to identify reliable welds visually (see *Diagram*).

Because of the many variables involved in the fabrication of welded assemblies, stringent checks are recommended. One successful procedure, for instance, requires the inspection of all components before assembly within a module. In addition, setup samples are prepared before the start of each shift by spot-welding lead materials of the type ready for production. These samples are checked, and the good ones are tested to



WELDED computer logic module potted in polyurethane foam.

A cross-section of the 40 subsystems incorporating 3500 electronic parts which go into TIROS III are framed by two satellites. All components must be thoroughly tested, precisely integrated and must function perfectly if the satellite is to perform successfully.

NASA's Hurricane spotting TIROS III maintains projects' fine performance record

With the successful launching of TIROS III, meteorologists for the first time will see the total cloud formations and measure the radiative energy balance of hurricanes which plague the eastern coast of North and Central America each year. For TIROS III was launched at this time for precisely this purpose. From information gained from TIROS III, meteorologists may learn much more about the birth and life cycle of tropical storms.

TIROS III DESIGN

Although the spacecraft configuration is essentially the same as the previous two highly reliable TIROS satellites, TIROS III has two wide-angle cameras and the National Aeronautics and Space Administration has placed new omnidirectional IR sensors aboard to measure thermal radiation from the earth and sun.

THIRD OF A FAMOUS FAMILY

TIROS III is the third of a highly successful series of experimental weather satellites which were developed, along with the associated ground equipment, for the NASA, under contract with the Goddard Space Flight Center, by RCA's Space Center. All of them have established "firsts" in the United States' space program.

TIROS II established a longevity record for a complex satellite. Still operating after nearly eight months and over 3300 orbits, TIROS II has transmitted over 34,000 photographs to the ground. Aside from its impressive meteorological achievement, historians may well point to this long-term performance as the first to prove that a satellite system could operate reliably for so many months in a space environment thus proving the feasibility of operational satellites.

TIROS I was the first satellite, carrying advanced television equipment, which sent photographs of the earth's cloud cover to meteorologists. From TIROS I's 23,000 photographs, meteorologists found that satellites could be used for weather observation and analysis. The pictorial information is particularly useful in the two-thirds of the world from which few or no weather observations are now available.

CONNOTATIONS FOR THE FUTURE

The TIROS series has proved beyond a doubt that the peaceful uses of space will benefit all mankind. Six nations participated in the utilization of information from TIROS II and more will take advantage of TIROS III. RCA is also already at work on the camera systems and space power supply for NIMBUS, the next generation of meteorological satellites.

If you are a professional physicist, engineer, or mathematician and interested in participating in such challenging projects and stimulating team efforts, contact the Employment Manager, RCA Astro-Electronics Division, Defense Electronic Products, Princeton, N. J. All qualified applicants are considered regardless of race, creed, color or national origin.

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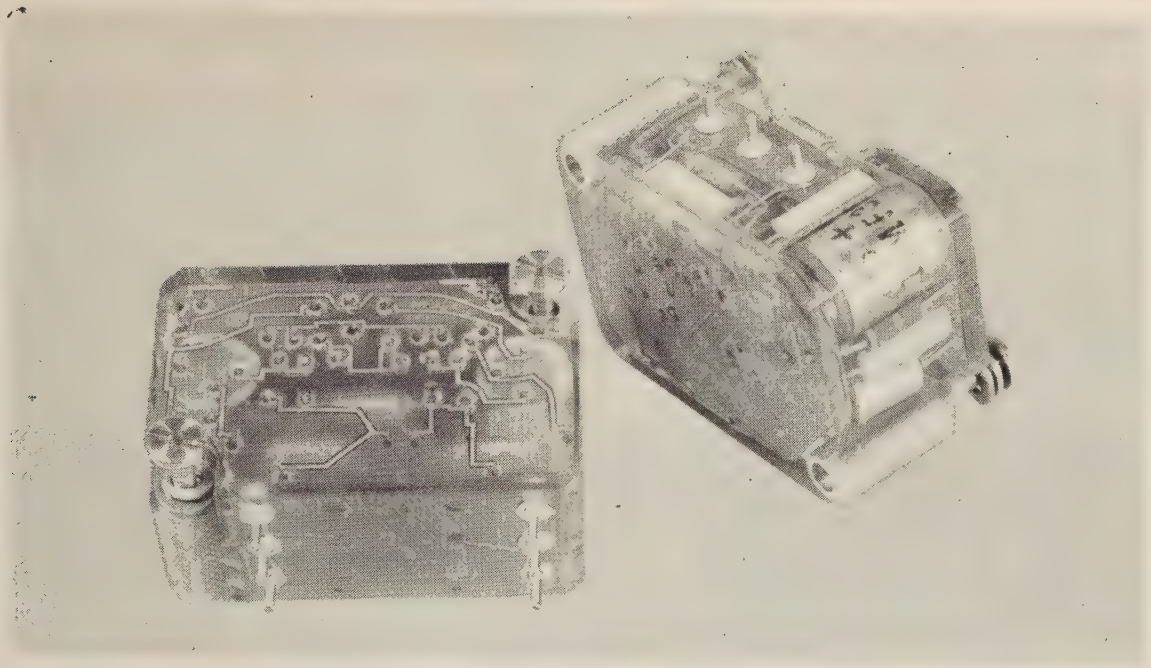


GIMBAL-MOUNTED module of welded matrix construction.

destruction. This procedure is expensive but it results in reliability levels that make it worth while.

Welding quality can also be checked by reading the power at the electrode tips. Welds are first made with an optimum set up. Once these have proved satisfactory in comparison with established standards, the instantaneous power readings at the electrode tips are recorded as production standards and all welding machines are adjusted to agree with them.

After a module is welded and electrically tested, it is encapsulated to protect it against environmental hazards and add substantially to its structural rigidity. For modular units with a dissipation on the order of microwatts, polyurethane foam potting is satisfactory. The normal method of application is to pour the foam into a preheated mold containing the preheated module. The mold is closed to provide a degree of restraint as the foam expands and is cured. The upper curing temperature limit depends on the degree of heating the most temperature-sensitive element in the module can withstand.

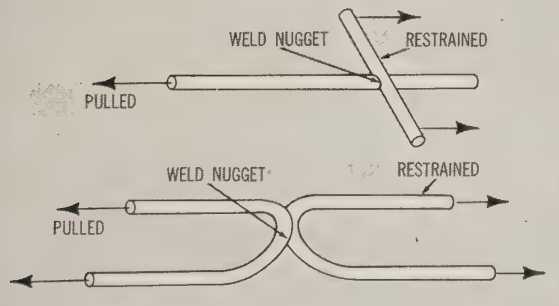
Modular units that dissipate higher power are embedded in an epoxy resin filled with metallic oxides or in an anodized aluminum heat sink. The embedment can take any shape and have inserts for screw mounting as an integral part. The modules we have embedded in polyurethane foam or epoxy resin showed not a single case of failure when they were vibrated at five g random noise for 24 hours. Modules embedded in plastic of course are difficult or impractical to maintain. They therefore should be designed cheaply enough so that they can be thrown away in case of trouble. If a large unit is involved, it should be subdivided into small, replaceable units.

Because the welding of electronic packages is still in its early stages, data must be continuously recorded and compared to provide operating standards for:

- voltage across welds as a function of time;
- electrode materials;
- the force range within which reliable welds are obtained;
- combinations of component lead materials and diameters;
- prewelding cleaning procedures;
- heat treatment after welding;
- vibration tests of welds.

As a rule, the weld area is smaller than the cross-section of the component lead. Therefore, though the weld may be as strong as the parent metal, it will probably fail before the lead. A weld with 50 per cent of the strength of the parent metal of the weakest lead material is acceptable.

BASIC CROSS-WELDS for evaluating weld reliability by destructive testing. In the weld at top, the short lead is restrained and force is applied to the long lead until separation occurs. The same principle is followed for the sample at bottom, which is an Instrom-machine torsion-tension-shear weld.



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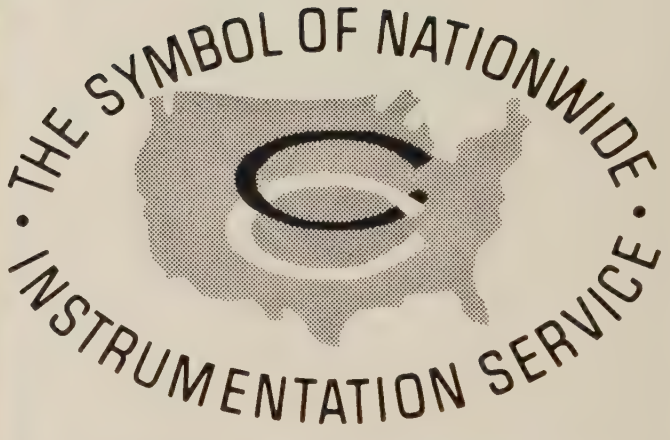

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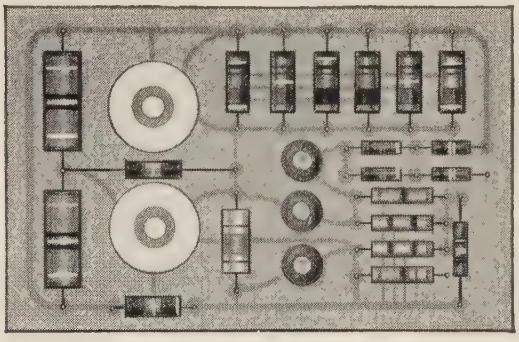

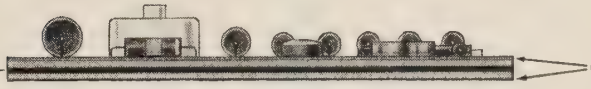

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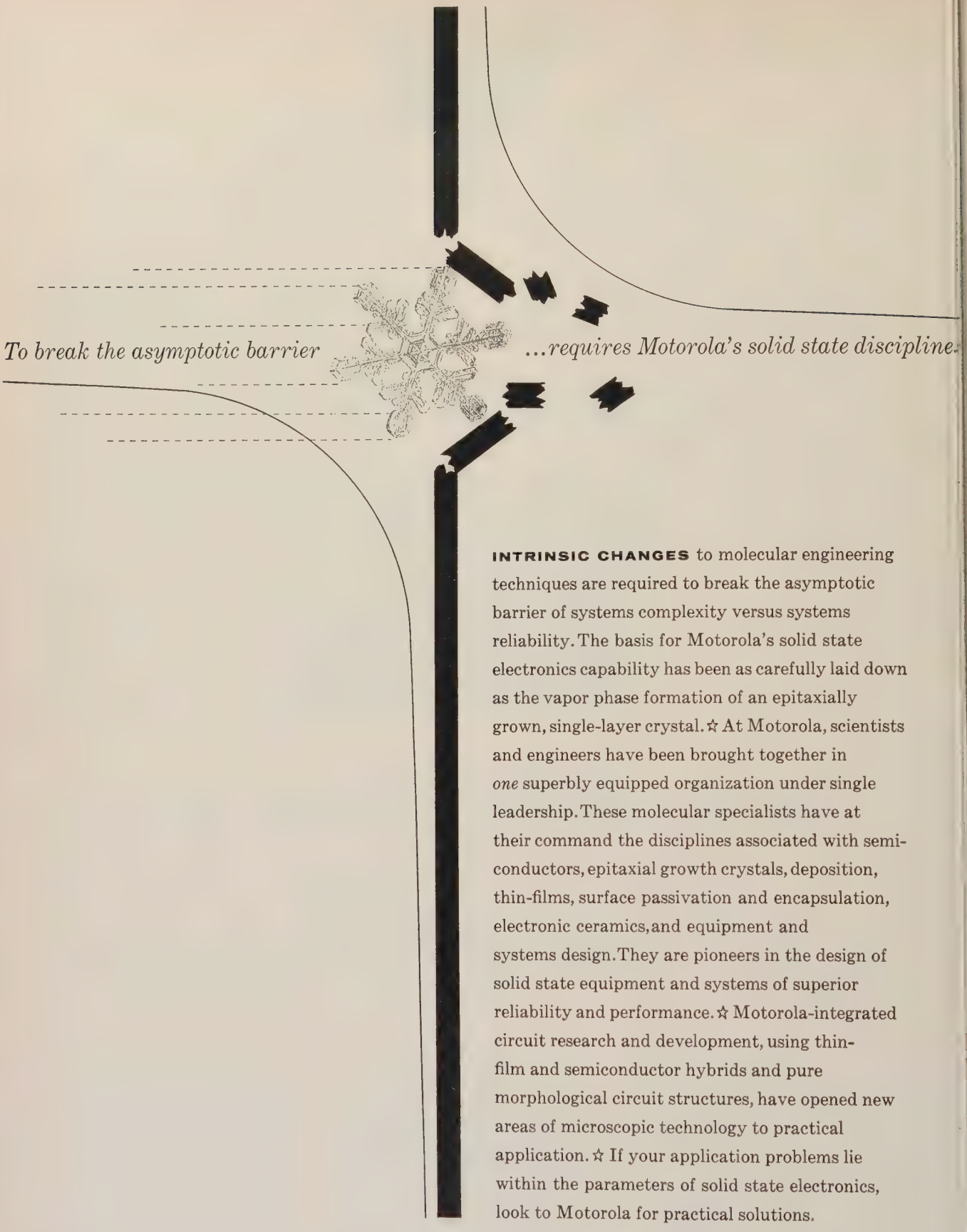

To break the asymptotic barrier ...*requires Motorola's solid state discipline.*

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SURVEY

by James Holahan and Bernard Kovit
Electronics Editor & Associate Electronics Editor

Maser R&D

Airborne Instruments Laboratory, Deer Park, N. Y. Working on traveling-wave, solid-state microwave, and millimeter-wave masers (no cavity types). Has operated electronically tunable traveling-wave masers at L- and S_c-bands and is packaging the S_c-band design to meet full Mil specs in telemetry applications. Working on a series of electronically tunable masers for the range from X-band up to the millimeter region and on a 35-kmc maser system for airborne ground-mapping radiometers.

Studying materials like ruby, emerald, and chromium- and iron-doped titania (rutile). Has started a laser development program and is working on harmonic spin

IN BRIEF

This survey of current R&D on masers—including infrared and optical, or laser, types—covers the work being done by 25 industrial and university groups in this country and one French company. It shows that today's typical maser program is designed to provide a better understanding of the basic phenomena of maser action and to point to new materials.

Much of this survey is based on the replies to a questionnaire sent out several months ago. Data on more recent developments, however, are also included—these were provided by some 15 of the groups in response to a second, follow-up questionnaire.

Typical Operational Solid-State Ruby Maser Amplifiers

	Type	Signal Frequency (kmc)	Pump Frequency (kmc)	Pump Power (mw)	Gain (db)	Bath Temp. (deg K)	Noise Temp. (deg K)	Bandwidth (mc)	Application
AIL	cavity	0.85-2.0 (tunable)	10.46-12.15	5-150	15 & 1.8 kmc			3.6 & 1.8 kmc	military system
	traveling wave	2.1-2.4 (tunable)	10.9-12.8	150	25			21	being packaged for ASD
BT	traveling wave	2.7-2.74 (tunable)	13.4-13.6	few	20-35	1.4	7.10	15-25	Echo receiver
	traveling wave	5.65 (tunable over 230 mc)	18.5-18.9	100	30-40	1.4	7.10	30	sky noise studies
Columbia	cavity	9	21	30	20	1.4	7.10	1	sky noise studies with 50-ft ONR radio telescope
	cavity	9.5	23.5	30	20	1.4		5	
Harvard	cavity	1.42	11.27	100		4.2	2.5	2	radio astronomy experiments to study hydrogen line
Hughes Aircraft	cavity	9.3	24	5-10	20-35	4.2, 77, 196	10	10	experimental in Army ECM & weather radar receivers; showed 12-18-db system sensitivity improvement
	cavity	9.3	K-band	10	30		65		pulsed-radar experiments

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coupling, a technique for pumping at less than the signal frequency.

American Optical Co., Southbridge, Mass.

Developing infrared masers using helium-neon gas as the active element in hollow glass filaments and pumping by self-discharge or inert gases in hollow glass filaments and pumping by a mercury arc.

Applied Physics Laboratory, The Johns Hopkins U., Silver Spring, Md.

Working on solid-state zero-field and conventional high-magnetic-field microwave masers for the range from X- through K-band (up to 35 kmc). Studying ways of getting high gain-bandwidth products with cavities. Materials to be used are ruby, iron, sapphire, and rutile.

Bell Telephone Laboratories, Murray Hill, N. J.

First BTL maser used lanthanum ethyl sulfate ($LaC_2H_5SO_4$) containing 0.5 per cent gadalinium and 0.2 per cent cesium. Crystal was cooled to 1.2 deg K, pump frequency was 17.52 kmc, signal frequency was 9.06 kmc.

All current maser amplifier work devoted entirely to traveling-wave types using the same basic slow-wave (comb structure) but different types of dielectric loading to shift the center frequency. Dielectrics include sapphire, ordinary ceramics, and rutile. A number of traveling-wave masers has been built (see *Table*). Adjustment of pump frequency and magnetic field yields a tuning range of 8-10 per cent.

Ruby is being used in operating masers. Many other materials are under study, including double-doped crystals (e.g., rutile doped with Cr^{3+6} and Fe^{3+5} and lanthanum ethyl sulfate doped with gadalinium and cesium).

Has developed several solid-state optical masers using dilute ruby, concentrated ruby, and calcium fluoride. Other materials are being studied for high temperatures.

Has developed a CW IR maser oscillator using a mixture of helium and neon gases and pumped by self-discharge. The mixture of helium and neon gases is contained in a glass tube about 40 in. long. Electrodes on the outside of the tube send a 28-mc current through the mixture, exciting the helium atoms. These higher-energy atoms transfer their excess energy to the neon atoms by collision. The neon atoms radiate the excess energy in the form of highly coherent infrared waves. Oscillations have been observed in lab models at 11,800, 11,530, 11,990, and 12,070 A. The highest observed power output was 15 mw at 11,530 A. The input power from the 28-mc energizing source was about 50 W, measured linewidth was in the 10-80-kc range, the angular spread of the beam was less than one minute of arc. Also experimenting with other gas mixtures.

Columbia U., New York, N. Y.

Working on some ammonia-gas molecular beam masers. Has built operational solid-state microwave maser for ONR radio telescope (see *Table*).

Developing optical maser using cesium vapor and pumped by violet light from helium discharge. Cesium emits into a cavity made up by the reflecting end plates of an optical interferometer arrangement. The interferometer selects proper wave mode for coupling to emitting atoms in a way that would be impossible with an ordinary cavity of similar large size. Theoretically this method should provide output powers on the order of a milliwatt with a millionth of the spectral width from a vapor lamp. The interferometer would directly generate a beam of about one minute of arc.

Has built 21- and 10-cm solid-state masers for radio astronomy. Research is underway on a six-millimeter solid-state maser amplifier.

C. G. de Telegraphie Sans Fil, Paris, France.

Has built operating cavity-type lab maser using chromium doped sapphire (ruby) in liquid-helium bath. Amplification is at three centimeters, square root of gain times bandwidth is about 150; noise temperature reportedly is eight deg K. Studying maser materials.

General Electric Co., Electronics Laboratory, Syracuse, N. Y.

Working on masers in sub-millimeter, IR, and visible regions, using ruby immersed in liquid nitrogen and at room temperature. Pumping by xenon, mercury, and tungsten lamps. Studying other crystals and gases for maser action.

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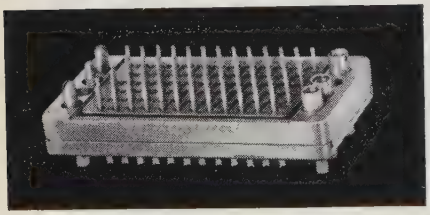

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GPL Div., General Precision, Inc. Pleasantville, N. Y.

Working on experimental optical masers, including deep-red and near-infrared types, and on theory for blue-light masers. Goal is a CW laser. Believes it knows the right materials to use in such a device. Studying rare-earth materials and system use of masers for USAF.

Harvard U., Cambridge, Mass.

Has built 1420-mc solid-state maser amplifier being used in radio astronomy experiments. First maser built by Harvard used crystals of $K_3Co(CN)_6$ containing 0.5 per cent $K_3Cr(CN)_6$. Signal frequency was 1.373 kmc; pump frequency, eight kmc; gain, 10 db (with pump power of 8.6 mw). Working on hydrogen-gas molecular beam maser generating 1420 mc at a linewidth of about one cycle and a power output of about 10^{-14} W.

Hughes Aircraft Co., Culver City, Calif.

Had NASA contract for ammonia-gas masers for satellite relativity experiments. Working on microwave solid-state masers, including their packaging for field use. Has built ruby masers whose gain-bandwidth product is over 300 mc and has gotten maser action in ruby at temperatures as high as 196 deg K (see *Table*).

Studying the use of strong, internal crystalline fields to provide energy levels in crystals at "hyper-frequencies," low-frequency pumping, and changing of the magnetic field to get outputs at higher-than-pump frequencies. Has installed maser in pulsed radar for experiments. Overcame saturation from pulse leakage by designing special low-loss ferrite switch. Maser virtually doubled the radar's range.

Was first to get laser action, using ruby at room temperature pumped by pulsed xenon light to get coherent 6943-A output in 10-kw, 500-usec pulses at a rep rate of one per minute and 30 mc linewidth.

International Business Machines Corp., Poughkeepsie, N. Y.

Has built two experimental masers using 0.1 per cent trivalent uranium ions in calcium fluoride and divalent samorium ions in calcium fluoride and generating coherent infrared at 2.5 microns and coherent light at 0.708 microns, respectively. Expects CW output with further development. Required pump power is only 0.02 per cent of Hughes ruby optical maser's requirement. The active element is immersed in liquid helium in a special dewar so that it does not come into contact with the liquid. Pumping is done by light from a xenon flash lamp.

ITT Federal Laboratories, Nutley, N. J.

Developing laser using ruby and a pump scheme similar to BTL's and Hughes' techniques. Working on infrared and microwave masers. The active element (silicon and indium antimonide) is immersed in liquid helium bath. ITT IR maser using a non-optical pump scheme has been reported in the press.

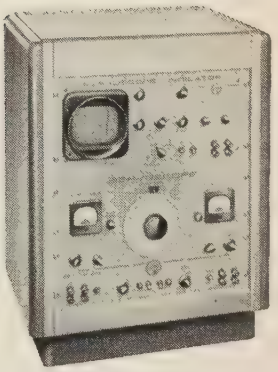
Lincoln Laboratory, Massachusetts Institute of Technology, Lexington, Mass.

Studying new type of optically pumped far-infrared solid-state maser using cyclotron resonance and fast and meanderline slow-wave structures and further development of superconducting magnets. Doing R&D work on materials and components for microwave, millimeter, sub-millimeter, and infrared masers.

Solid-state masers in lab operation include pulsed optical ruby masers and CW masers using iron-doped rutile for operation at eight and four millimeters (35 and 70 kmc). Higher-frequency operation expected when adequate pumping sources become available. The eight-millimeter maser is easily tunable over a six kmc range by adjustment of the external magnetic field. It operates with a super-conducting solenoid and without an external field supply. Masers in systems operation include a UHF type using chromium-doped potassium cobalticyanide and operating at 440 mc, which was used in the Millstone Hill radar to reach Venus; an X-band ruby type in the tracking radar at Arbuckle Neck near Wallops Island, Va.; two X-band ruby types now being installed for satellite communications tests; and an eight-millimeter rutile type for experimental CW radar.

The Martin Co., Orlando, Fla.

Has developed the first optically pumped microwave-output maser—a cesium vapor oscillator that is pumped by a cesium vapor lamp (8521.1 A) and emits coherent radiation at 9.92.651 mc. Linewidth



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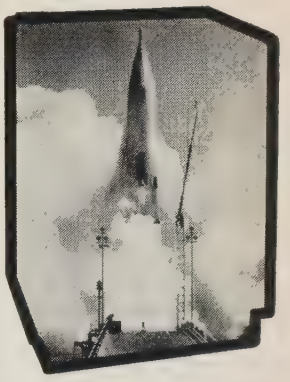

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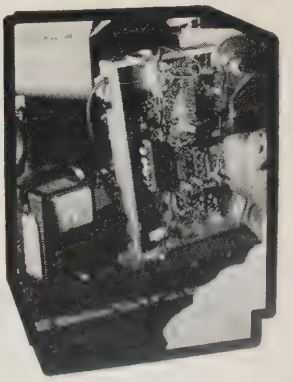

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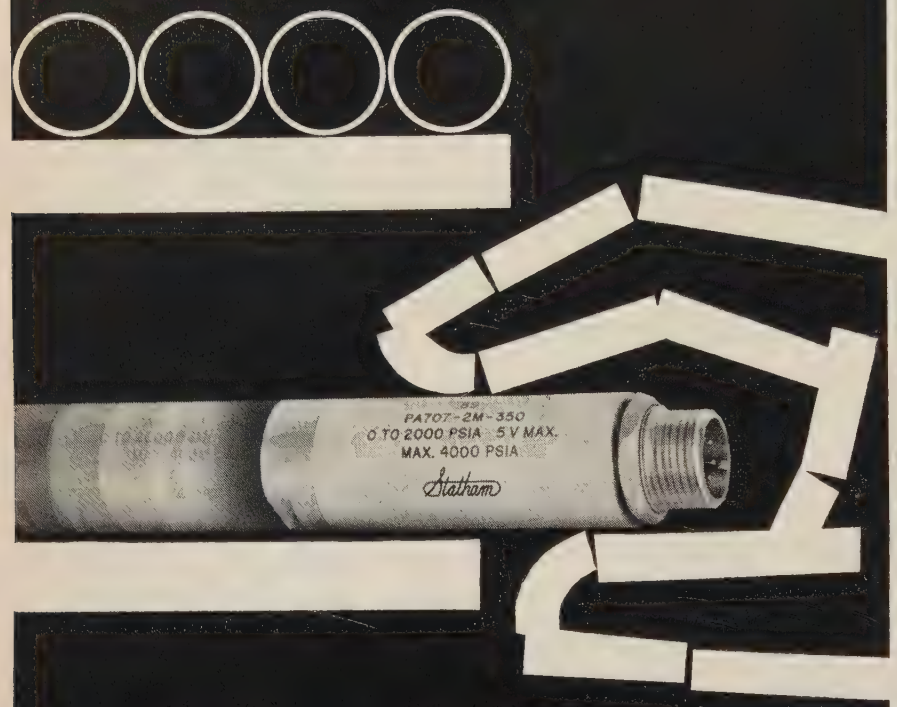

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is calculated as 0.9 cps; power output, as 10^{-14} W. The cesium vapor capsule is set in a high-Q, X-band cavity. Studying pump schemes and the use of other gases, including thalium, for a family of maser oscillators to cover the range from X-band to the millimeter region.

Melabs, Palo Alto, Calif.

Recently completed three-year USAF study contract on microwave masers (mainly S-band cavity and traveling-wave types). Has built lab masers, using ruby as the active material.

U. of Michigan, Institute of Science & Technology, Ann Arbor, Mich.

Trying to increase sensitivity of its operational maser. Has developed X-band maser using wide-band cavity and built-in closed-cycle helium liquefier (see *Table*). Studying new materials, especially gash (*g*uanadine *a*luminum *s*ulfate hexahydrate), a ferroelectric that is the host crystal for chromium ions. Gash works well at 11 kmc (single frequency) and liquid-helium temperatures and shows very interesting electron-nuclear double resonance phenomena.

First to use ruby in an operating maser — a 9.22-kmc amplifier pumped by 24.2 kmc in a 4.2-deg-K bath. Has laser operating in lab that uses ruby pumped by pulsed xenon flashes to emit R1 line (6900 A). Studying the use of lasers in high-resolution range finders and laser materials.

Philco Corp., Research Div., Philadelphia, Pa.

Studying maser action using ruby in traveling-wave configuration. Gains of 1.5-2 db/in. have been achieved over the tunable range (7-10.5 kmc) and as high as eight decibels at 130 mc bandwidth. Magnetic field is provided by a superconducting solenoid that can produce a uniform field sufficient for gains of more than 20 db.

PRD Electronics Co., Brooklyn, N. Y.

Building a commercial ammonia maser. Has made design improvements in original gas maser, including the use of $N^{15}H_3$ isotope of ammonia (instead of $N^{14}H_3$), double cavities, a performance-enhancing beam focuser, and a cold plate to solidify expended ammo-

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ACCLIMATING MAGNETIC DRUMS TO SPACE

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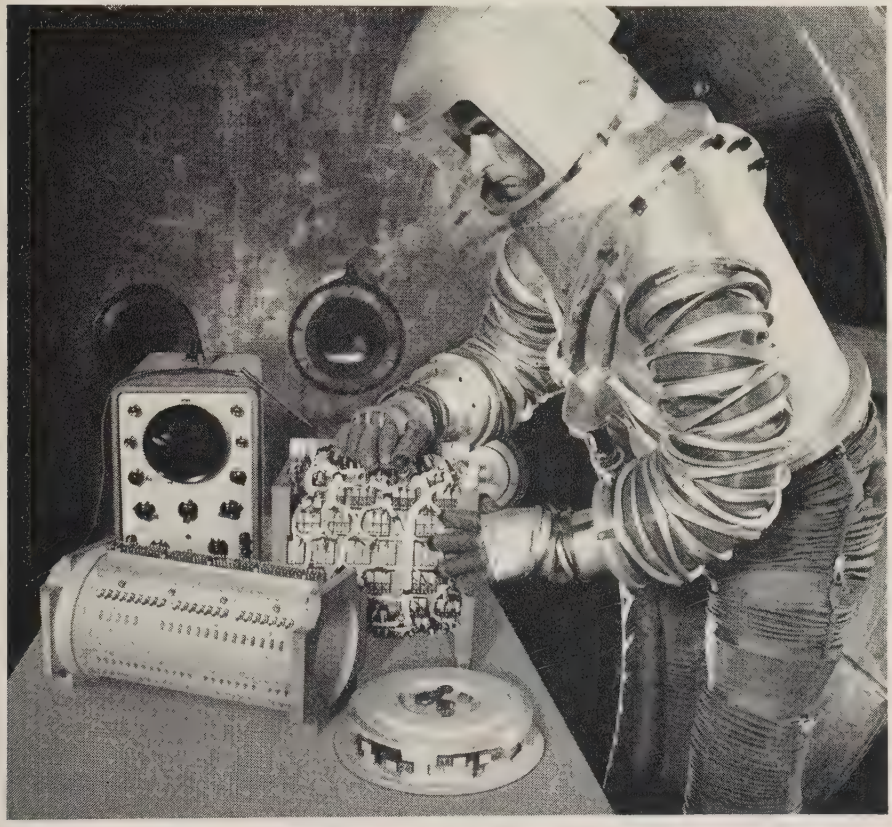
Litton Systems engineers who have contributed significantly to the improvement of the magnetic drum – a key element in Litton's ground and airborne electronic data systems – are now preparing this highly essential component for space vehicles. Problems they are investigating include friction created by the absence in space of the boundary-layer lubrication phenomenon, the erratic behavior of electrons at hypertemperatures, and the effects of vibration caused by post-launch acceleration.

Aspects of these problems were recently investigated by Litton engineers who subjected a Litton-developed, 6-inch lightweight magnetic drum and associated contact magnetic recording heads to a series of high-vacuum vibration and altitude tests. Drum and heads (without built-in lubricants) were operated at simulated altitudes in excess of 300,000 feet and vibrated at frequencies as high as 50g rms (bandwidth 20 to 2000 cps).



Primary objectives of the high-vacuum tests were to determine: (1) Tendency of heads to bounce on drum surface under shock or vibration. (2) Relationship of recording signal level and equipment wear to contact head pressure. (3) Dependency of head flutter on air density.

Both drum and recording heads operated without loss of information during these tests, indicating that additional tests to prove the feasibility of magnetic drums, contact heads, and associated electronics for outer-space applications are fully warranted. The next series of tests will be designed to determine the effects of cosmic radiation on electronic and mechanical equipment. Still other tests will then be conducted to study the performance of equipment in the temperature extremes of space.

Litton has successfully developed and is now producing complete data systems incorporating magnetic drum storage and retrieval subsystems that use contact heads for reading and writing digital data. Litton engineers have little doubt that what they have accomplished for ground and airborne systems, they will also be able to do for space systems.

Electronic engineers intrigued by problems and activities of this sort and anxious to negate or prove out Litton approaches are invited to write, phone, or visit. Contact Don Colvin, Litton Systems, Inc., Computer Systems Laboratory, 5500 Canoga Avenue, Woodland Hills, California. Or telephone DIamond 6-4040.

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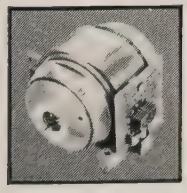

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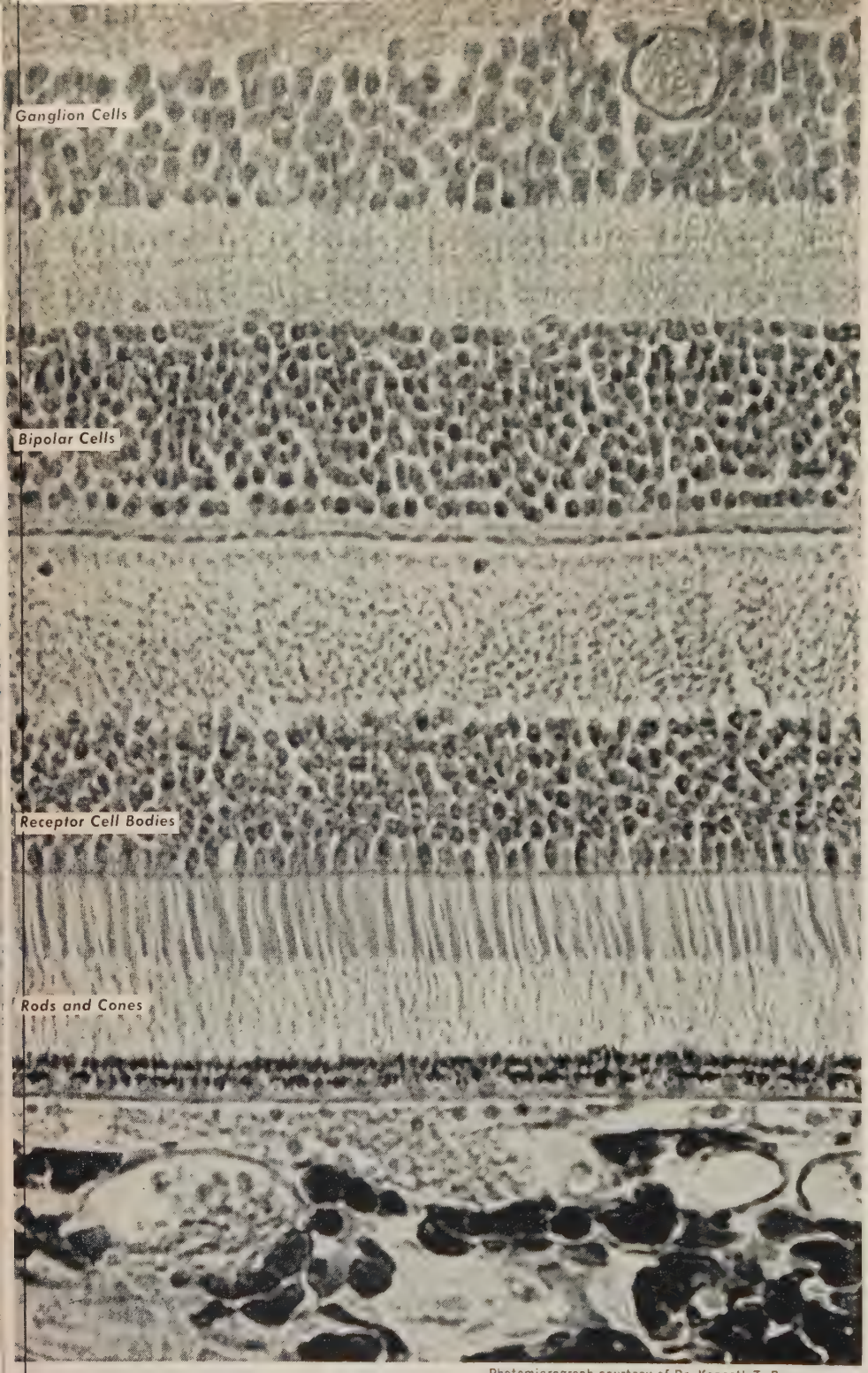

Photomicrograph courtesy of Dr. Kenneth T. Brown

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nia molecules. Frequency of oscillation of $N^{15}H_3$ is 22.78941 kmc. Working on long-time, sealed-off molecular beam maser for field use and aerospace vehicles.

Radio Corp. of America, RCA Laboratories, Princeton, N. J.

Studying chromium-doped and iron-doped rutile for microwave masers. Has built cavity devices using these materials at nine and 24 kmc. Studying harmonic pumping and idler doping with iron-doped rutile for amplifications of up to 70 kmc. For lower frequencies, has built a traveling-wave maser that uses dielectric slowing only in chromium-doped rutile and can provide very wide tunable bandwidth. Studying characteristics of pulsed optical ruby and calcium fluoride masers and working on the synthesis of new materials that can be used as CW generators to provide coherent radiation in the optical and infrared regions.

Raytheon Co., Research and Microwave & Power Tube Divs., Waltham, Mass.

Marketing a light-cavity laser using a reflector system to direct light into a synthetic ruby crystal much more efficiently than was done in the original ruby lasers. A pencil-shaped xenon flash tube five inches long and ¼ in. in diameter is used inside the reflective cavity together with the ruby rod. Requires only 150 J input power to produce laser action lasting 100 usec. The reflector's walls are elliptic and mirrored with silver. Attempting to develop a CW laser along these lines.

Has demonstrated a gaseous optical maser using helium and neon to produce a continuous 1.15-micron output. Device is similar in principle to BTL's gaseous CW optical maser but "incorporates several novel features in a simplified design and marks a significant step toward a practical, dependable, continuously operating source of coherent infrared energy."

Sperry Gyroscope Co., Air Armament Div., Great Neck, N. Y.

Building a gas laser patterned after BTL's CW devices, working on ruby lasers and doing basic materials studies.

Stanford U., Electrical Engineering Dept., Stanford, Calif.

Has developed S-band traveling-wave maser using "meander-line"

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slow-wave circuit giving a much wider tuning range than do comb circuits at the same slowing factor. Studying harmonic cross-relaxation and pumping; nitrogen-temperature cavity maser, broad-banded by multiple cavities; and "staircase" maser.

Signal Corps and Air Force OSR contracts covering optical masers, including studies of rare earths in the very far infrared and for CW and fiber-optics designs as well as laser action in ruby.

TRG, Syosset, N. Y.

USAF contract to study media and techniques to support optical oscillation using solid and gaseous matter.

Has laser similar to Hughes' but pumped by continuous (rather than pulsed) mercury arc and operating at liquid-helium instead of room temperatures. Output is 7009 A. Has a self-discharged, pumped, krypton-mercury-vapor IR maser oscillator emitting at six microns and a cesium-vapor type pumped by a continuous helium arc and emitting at seven-microns.

Trion Instruments, Inc., Ann Arbor, Mich.

Has long-range R&D program on laser applications and materials. Working on a system with which it hopes to get output powers of around 1-10 Mw (some three orders of magnitude above that of present ruby lasers). Using mostly pink ruby, but plans to concentrate on dark ruby, helium and neon gases, and possibly glass substances. Designed laser with which U. of Michigan researchers produced a deep blue second-harmonic beam from primary red. The second harmonic (3471.5 A) was produced by focusing the laser's output beam (6943 A) into a quartz crystal.

Varian Associates, Palo Alto, Calif.

Researching solid systems at new wavelengths in the visible and infrared regions. First demonstrated simultaneous laser action in red ruby at wavelengths of 7010 and 7040 A. Gas laser program underway.

Westinghouse Electric Corp., Air Arm Div., Baltimore, Md.

Has developed a four-level microwave maser amplifier for ASD using a new material for amplifying signals whose frequencies are considerably higher than the pump frequency.

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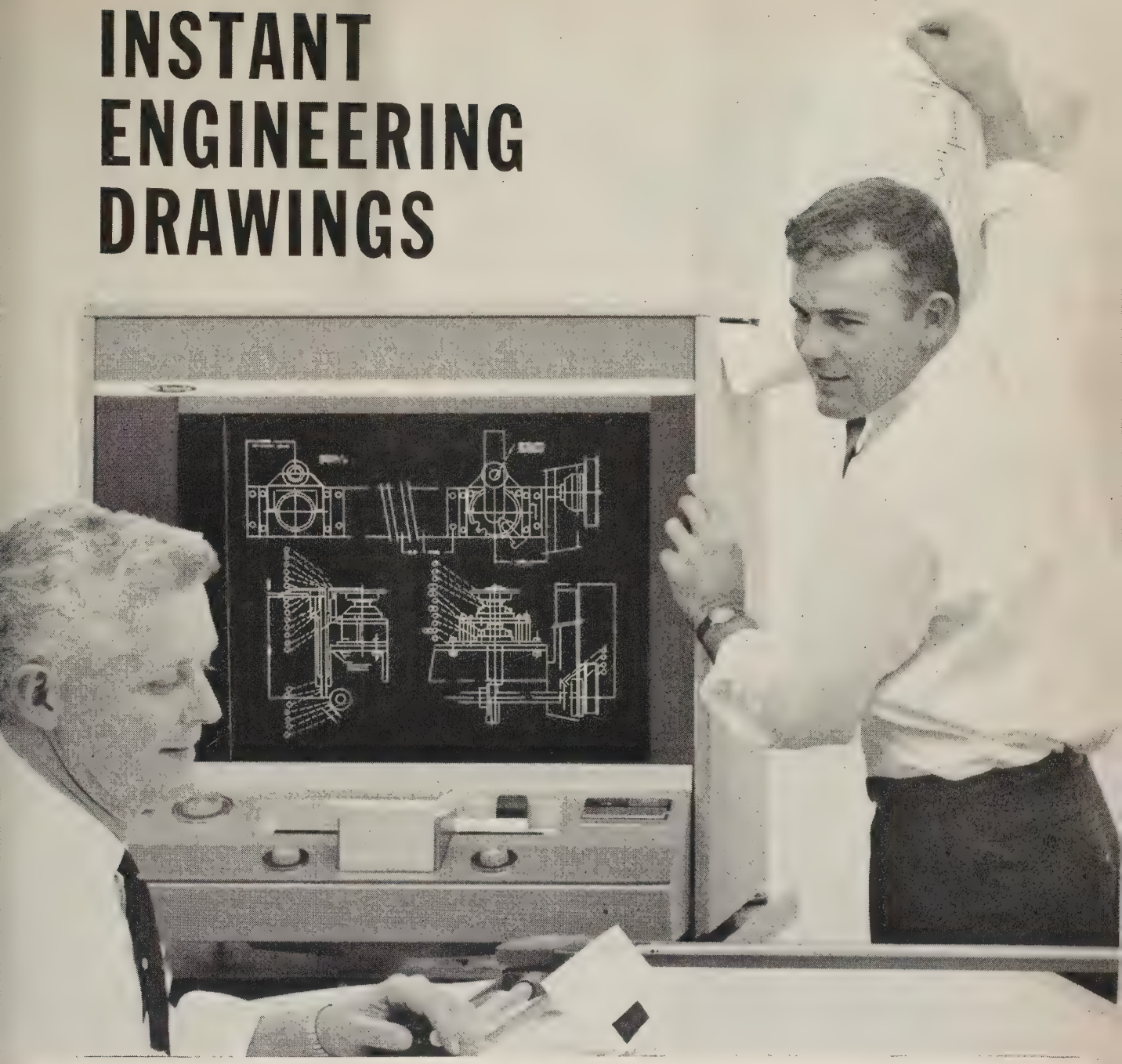
INSTANT ENGINEERING DRAWINGS



FASTER PRINTS MEAN FASTER PRODUCT DEVELOPMENT, FASTER PRODUCTION. Imagine locating a drawing or record in seconds. Imagine having a work-size print in just 8 seconds. All this, and more, can happen when your drawings and records are on microfilm . . . with FILMSORT® Aperture Cards and THERMO-FAX "Filmac" Reader-Printers. This is the way many companies are saving valuable engineering and drafting time, saving the cost of full-size print preparation, saving space, and saving print distribution costs. The cost? Far less than you would expect for such amazing efficiency. Find out now how you, too, can put microfilm to work—get Instant Engineering Drawings when you need them, where you need them—with 3M Microfilm Products.

3M Company Dept. FCM-101, St. Paul 6, Minn.

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MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

this is a man you should know – a Delavan fuel injection specialist

COMPLETE ENGINEERING IS HIS RESPONSIBILITY

Engineering at Delavan doesn't end at the drawing board. It follows through all phases of design, production and testing to be sure the final product meets customer specifications and Delavan's performance standards. This is Mike Soth, a Project Engineer on main engine fuel nozzles, checking on the secondary finishing of a metering set. He is one of Delavan's 49-man engineering team who is mainly responsible for Delavan's reputation for quality and reliable performance. Tell us your requirements.

get to know Delavan fuel injection specialists

DELAVAN
Manufacturing Company
WEST DES MOINES • IOWA

No. 92 on Reader Service Card

Check Inquiry Form on Page 155

CIENTISTS AND ENGINEERS:

ollow-On Atlas Programs Mean New, Long-Range Opportunities.

ow operational, the Atlas weapon system stands as a nique symbol of scientific, engineering and military chievement. The design, development and testing of this liable missile was an undertaking of immense complexity. cientists and engineers at General Dynamics | Astronautics orked constantly at the most advanced state of the various ts involved. Boldly, they introduced and proved entirely ew concepts of rocketry, and in record time they developed e Atlas.

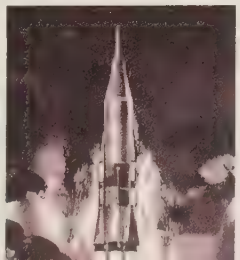
ne same depth of imagination and technical daring is now work modifying and adapting this sophisticated machine r a variety of civilian and military space missions. Dozens specialized orbiting and inter-planetary vehicles will de- nd upon the power of Atlas to thrust them into space. nese programs reach far into the future and require the ills of highly resourceful engineers and scientists in many chnical disciplines.

tlas is the free world's first intercontinental ballistic mis- e; the first missile to travel more than 9,000 miles across the earth's surface; the only one to lift itself into orbit. Atlas marked the first use of swivel engines for directional control and it was the first to use airframe skin as fuel cells.

Many more "firsts" lie ahead for this reliable rocket. If you are the sort of inventive engineer or scientist who can contribute ideas and solutions to the problems surrounding the mastery of space, you and General Dynamics | Astronautics have a common interest.

You'll find most of the details on this and the following page, plus a convenient inquiry card. If the card has been removed, or if you wish to furnish or request more detailed information, write to Mr. R. M. Smith, Industrial Relations Administrator-Engineering, Dept. 130-90, General Dynamics | Astronautics, 5692 Kearny Villa Road, San Diego 12, Calif. (If you live in the New York area, please contact Mr. T. Cozine, manager of our New York Placement Office, 1 Rockefeller Plaza, CIrcle 5-5034.)

GENERAL DYNAMICS



ASTRONAUTICS

(Formerly CONVAIR | ASTRONAUTICS)

ENGINEERS AND SCIENTISTS

General Dynamics | Astronautics is located in San Diego, California, the third fastest growing community in the United States. It is situated 10 miles north of the Mexican border and a little over 100 miles south of Los Angeles.

Immediate openings exist in the following areas:

SCIENTISTS & ANALYTICAL ENGINEERS: With Ph.D or Sc.D for electronics and physical research; computer analysis and application; and instrumentation development.

ELECTRONIC DESIGN & TEST: Communication systems and data transmission design; logical circuitry; automatic control systems; and electronic packaging. BSEE plus appropriate experience required.

MECHANICAL DESIGN: BSME or AE for pneumatics, hydraulics, and fluid systems design and test. Also missile GSE and missile structures designers.

RELIABILITY ENGINEERING: San Diego openings exist for experienced engineers with applied higher mathematics education, preferably in statistics; higher degrees preferred. Circuit analysis with transistor and diode experience is also desirable.

PERSONNEL SYSTEMS (MAN/MACHINE ANALYSIS): Specialists capable of evaluating the personnel function from a systems standpoint. Requires analytical approach to applying manpower to an existing system at the customer level. Broad technical systems background, with emphasis on human relations is essential. Assignments involve analysis of manpower requirements and applications for a weapon system, including equipment, procedures, time studies, logistics and training. Degree required, preferably in industrial engineering, business administration or industrial psychology.

ENGINEERING WRITERS: With 2 years' college and 1-3 years' experience in preparation of TCTO's; Operations, Maintenance, and Overhaul manuals.

BASE ACTIVATION: Design or liaison engineers with BE in ME or EE and experience in electrical or mechanical systems are required for liaison work at missile launching complexes, or design support work on launch control equipment, propulsion systems, automatic programming and missile checkout equipment operations. Assignments are at Salina, Kansas; Lincoln, Nebraska; Altus, Oklahoma; and Abilene, Texas. Also some openings in San Diego.

FIELD TEST ENGINEERS: Electrical engineers for test and validation of complex power electrical systems using standard commercial equipment. Trouble-shooting and checkout of ground electrical equipment including lighting, systems through missile-borne power distribution, fire alarm instrumentation and control. Must be thoroughly familiar with motor generators, motor control centers. AC and DC power and control circuits. Openings at Vandenberg and Edwards AFB, Calif., Cape Canaveral, Fla.

If you desire to become part of this great team, we urge your prompt inquiry on the attached Engineering Placement Inquiry.

Technical openings also exist in other specialties. Write Mr. R. M. Smith, Industrial Relations Administrator-Engineering, Dept. 130-90, General Dynamics | Astronautics, 5692 Kearny Villa Road, San Diego 12, California. (If you live in the New York area, please contact T. Cozine, Manager of our New York placement office, 1 Rockefeller Plaza, CIrcle 5-5034.)

GENERAL DYNAMICS | ASTRONAUTICS IS AN EQUAL OPPORTUNITY EMPLOYER

GENERAL DYNAMICS

ASTRONAUTICS GROUP

(Formerly CONVAIR | ASTRONAUTICS)

S/A EMPLOYMENT INQUIRY FORM

October 1961 • Good until December 15 • Confidential • Not an application for employment

THIS INQUIRY FORM is designed to make it easier for you, our engineering reader, to explore employment opportunities in the aerospace industry.
Here is what you do:

- Tear out this page.
- Check off the organization(s) listed below that you would like us to contact. Please use a typewriter or pencil—ink will not reproduce.
- Turn the page over and answer the questions.
- Mail this form in a stamped envelope to:

Engineering Reader-Service Dept.
SPACE/AERONAUTICS
205 E. 42nd Street
New York 17, New York

We will promptly forward a copy of your inquiry form to each of the organizations you specify. If your experience and background matches their requirement, they will get in touch with you at your home.

I am interested in the employment opportunities at:

☐ AiResearch Mfg. Co.	160	☐ Motorola, Inc.	138
☐ Garrett Corp.	160	☐ Northrop Corp.	157
☐ General Dynamics Astronautics	151, 152, 153, 154	☐ Pratt & Whitney Aircraft	159
☐ Hughes Aircraft Co.	20	☐ Republic Aviation Corp.	161
☐ Lockheed Aircraft Corp.; Georgia Div.	13	☐ Singer Inc. HRB; A Subsid. of the Singer Mfg. Co.	158
☐ Martin Company, The Orlando Division	91	☐ Space Technology Labs.	30
☐ Minneapolis Honeywell Regulator Co., Aero Div.	183	☐ United Aircraft Corp; Pratt & Whitney Aircraft	159
☐ Mitre Corp.	252		

Some of the recruitment advertising in this month's issue of SPACE/AERONAUTICS may have arrived too late for listing. In such cases, just note the name of the organization and page on which the ad appears. Please refer only to this month's ads that direct you to this Inquiry Form.

Name of organization _____ _____

Page on which ad appears _____ _____

NOTE: If you have an immediate interest in any special employment advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We would appreciate it if you would mention SPACE/AERONAUTICS in your covering letter.

Check Inquiry Form on Page 155

CONFIDENTIAL EMPLOYMENT INQUIRY FORM

Please type or print

FIELDS OF INTEREST—note the general fields in which you would like to work (e.g., basic research, dynamics, structures, propulsion, electronics, testing, production, ground support, etc.):

_____

_____

_____

_____

SPECIALIZED ENGINEERING EXPERIENCE—describe specific technical areas in which you have worked:

_____

_____

_____

_____

_____

_____

EMPLOYMENT—where are you now working and for whom did you work before that?

Employed by 1._____	2._____	3._____
City & State_____	_____	_____
Years_____ to_____	_____ to_____	_____ to_____
Title or Job Function_____	_____	_____
_____	_____	_____

DEGREES—list your college and university degrees:

School_____	_____	_____
City & State_____	_____	_____
Years_____ to_____	_____ to_____	_____ to_____
Degree_____	_____	_____

SPECIAL TRAINING: Briefly describe any special industry, military, or scholastic training:

_____

_____

_____

PERSONAL DATA:

Name_____ Age_____

Home Address_____ Home Phone_____

City & State_____ U. S. Citizen ☐ Yes ☐ No*

* If not, when do you expect to become a citizen?_____

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to SPACE/AERONAUTICS.

Do you share his driving determination to know?

An unsolved problem is a nagging challenge to him. The word "impossible" is an impertinence.

Are you cut from the same cloth as this man? Then come to Northrop where you can work in the fringe of the future on such projects as space guidance and astronertial navigation systems, aerospace deceleration and landing systems, magnetogasdynamics, in-space rescue, repair and refueling techniques, laminar flow control, automatic test equipment and world-wide communications systems.

More than 70 such programs are now on the boards at Northrop, with many challenging problems still to be solved, and new areas of activity constantly opening up for creative research. Whatever your specialty, drop us a line now if you want to find out more about the Northrop challenge.

NORTHROP

NORTHROP CORPORATION, BEVERLY HILLS, CALIFORNIA

WHERE ENGINEERING AND PRODUCTION JOIN FORCES

HRB-SINGER MANUFACTURING SERVICES DIVISION*

Exciting careers in technical production are attracting engineers with the highest qualifications to HRB's Manufacturing Services Division. This unusual production facility is fabricating state-of-the-art components, sub-assemblies of major defense systems and complete infrared reconnaissance systems.

The Division maintains the following modern facilities: Production Department, Mechanical Design and Drafting, Etched Circuitry, Machine Shop, and Quality Control and Testing. These facilities offer the engineer the opportunity to choose his work from all lines of technical production, from conception and design to fabrication, check out and field test. Close liaison with HRB's R and D departments helps the Division engineer keep abreast of new concepts and developments in the industry.

In addition to this excellent technical environment, HRB offers unusual employee benefits. These include company-paid graduate study at The Pennsylvania State University, generous hospitalization, life insurance and vacation programs as well as a company-paid retirement program.

If you are interested in learning more about career opportunities at HRB-Singer, write George H. Rimbach, Supervisor of Personnel, Dept. R-3.

**for technical data write Dept. MSD.*

HRB

HRB-SINGER, INC.

A SUBSIDIARY OF THE SINGER MANUFACTURING COMPANY

Science Park, P.O. Box 60, State College, Pa.

Investigating Employment Opportunities?

Want more information about employment opportunities offered by companies advertising in this issue? Then be sure to give complete data about your job interests, experience and education when filling in the "Employment Inquiry" form.

Although not an application for employment, it provides employment managers with information to evaluate your capabilities—and in turn give your request immediate consideration.

Check the "Employment Inquiry" form for details.

Check Inquiry Form on Page 155

space age opportunities in . . . .

ENGINEERING and SALES

The growing role of Pratt & Whitney Aircraft in the national aerospace program is apparent in the research and development projects and long-range product planning being conducted at their EAST HARTFORD, CONNECTICUT FACILITY.

At present, openings exist at various experience levels in research, design, development, and sales for engineers and scientists (BS through PhD) with experience in the following fields:

- ROCKETS
- NUCLEAR POWER
- ROTATING MACHINERY
- MAGNETOHYDRODYNAMICS
- FUEL CELLS
- CRYOGENICS
- HYPERSONIC PROPULSION
- THERMIONIC & THERMOELECTRIC CONVERSION

ENGINEERING

ELECTRICAL ENGINEERS
for analytical and experimental investigations in advanced rotating electrical machinery including cryogenic and very high temperature high speed machines.

AERO THERMO ENGINEERS
for performance and optimization studies of all types of advanced power plants and vehicle systems.

APPLIED SCIENCE
for advanced work in the fields of nuclear, chemical, and direct energy conversion equipment.

NUCLEAR ENGINEERS
for work with advanced concepts in reactor systems and components.

MECHANICAL DESIGN ENGINEERS
for design work on all types of advanced propulsion systems.

MATERIALS ENGINEERS
for material application studies for advanced propulsive devices.

CERAMIC ENGINEERS
for refractory materials studies for advanced power plants.

STRUCTURAL MECHANICS ENGINEERS
for elastic and plastic analysis of structures of homogeneous and heterogeneous construction.

THERMAL STRESS ANALYSIS
for methods evaluation of temperature control in composite structures.

MECHANICAL METALLURGISTS
to integrate metallurgical concepts into structural design of advanced propulsive devices.

ANALYTICAL STRUCTURES ENGINEERS
to apply imagination and ingenuity to the solution of advanced structural problems.

VIBRATION ENGINEERS
to apply aero-elastic theory in the solution of complex flutter problems.

WEIGHTS ENGINEERS
to perform analytical weight studies on advanced propulsive devices.

SALES

As a result of expanded sales activities, a number of positions at all levels of our Sales organization are available for graduate engineers to promote the sales of Pratt & Whitney Aircraft propulsion systems in new vehicles under consideration or development for marine, missile and space applications. These positions offer opportunities in:

PROGRAM PLANNING AND TECHNICAL SALES
Planning of broad sales programs for and the sales promotion of advanced products—entails liaison with government agencies, military and scientific personnel.

SALES ENGINEERING
Responsible for all sales activities with aerospace manufacturers in connection with the application, sale, installation and operation of current and advanced propulsion systems.

SALES OPERATIONS
Analysis and evaluation of advanced programs and markets; the provision of all sales engineering services.

☆

Educational Advancement—

Engineers at Pratt & Whitney Aircraft have an unusually fine opportunity to continue their formal education under the United Aircraft Corporation Graduate Education Program with full tuition costs being paid directly to the institutions involved for those who successfully complete the requirements for advance degrees. Excellent courses are offered at the Rensselaer Polytechnic Institute Hartford Graduate Center located a few miles from our East Hartford Plant as well as at other fully accredited schools in Connecticut.

Please submit your resume, including minimum salary requirements, to:

MR. P. R. SMITH, OFFICE 75

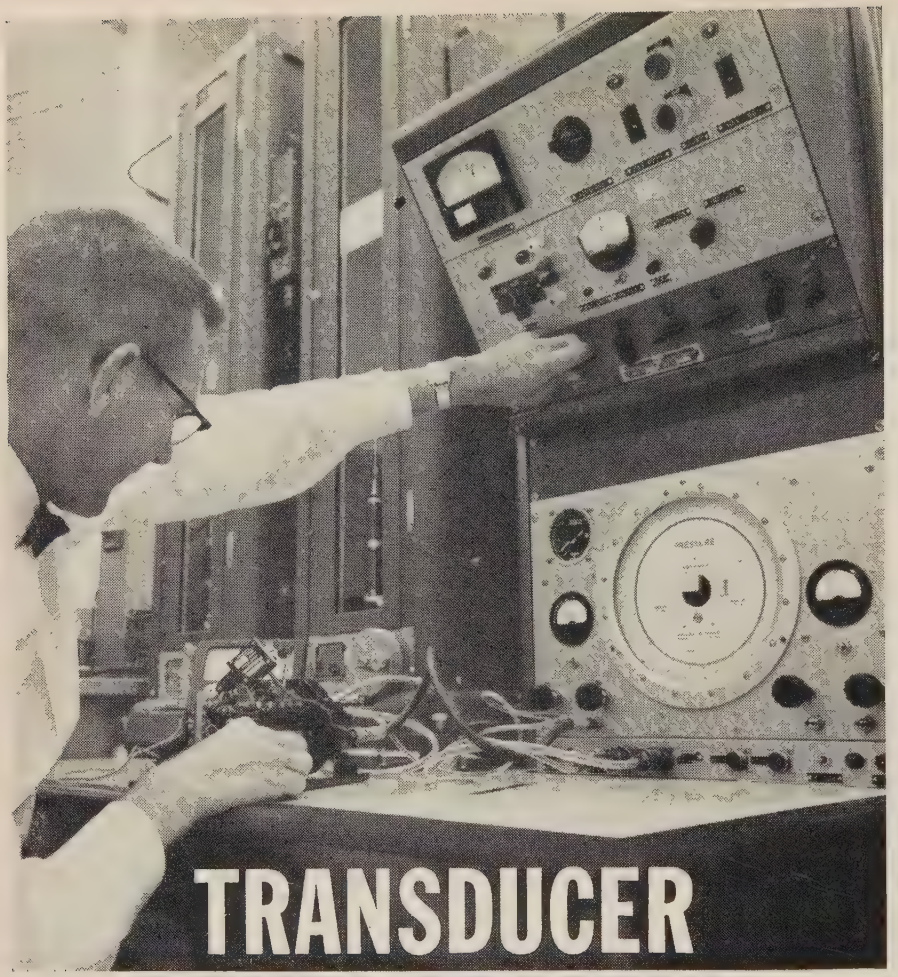
All replies will be handled promptly and in complete confidence.

PRATT & WHITNEY AIRCRAFT

DIVISION OF UNITED AIRCRAFT CORPORATION
EAST HARTFORD 8, CONNECTICUT

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Check Inquiry Form on Page 155



TRANSDUCER DEVELOPMENT ENGINEER

An important position is open for a mechanical engineer to design and develop transducer computer packages used for supplying basic aerodynamic data with extreme accuracy.

This work also involves synthesis of transducer outputs to compute information such as true angle of attack and yaw, free stream static pressure, rocket or jump angle and absolute air density at flight altitude.

Valuable experience would include the utilization of air data for armament, fire control and autopilot; jet engine pressure ratio indicators and engine inlet controls.

At least three years experience is necessary, and an MS degree is highly desirable. Location of this assignment will be in AiResearch's new electronic-electromechanical facility.

U.S. citizenship or previous security clearance required. Garrett is an "equal opportunity" employer. Send complete resume to Mr. Thomas Watson.

THE GARRETT CORPORATION
AiResearch Manufacturing Division
9851 So. Sepulveda Blvd., Los Angeles 45, California

ATTENTION ALL ENGINEERS

If you are seeking new job opportunities be sure to read all employment advertisements in this issue — both in this Special Section and throughout the magazine

CLASSIFIED

EMPLOYERS SPONSOR CAREER CENTER

Interview Engineers in New York, October 10-13

LOCATION: **HENRY HUDSON HOTEL**
358 W. 58th St. (opp. Coliseum)
PHONE: CIrcle 6-5015
TIME: 10 A.M. to 9 P.M. daily
Registration is free and confidential.
No charges at any time.

CAREER CENTER®
Career Centers are a service of Careers Incorporated, 770 Lexington Ave., New York 21, N. Y.
ADVANCE REGISTRATION: OCT. 8 & 9 AT THE HENRY HUDSON!

Check Inquiry Form on Page 155

ELECTRONICS ENGINEERS • PHYSICISTS

The Role of Electronics Engineers IN WEAPON SYSTEM MANAGEMENT AT REPUBLIC

As one of the top 15 Prime Contractors to the DOD, Republic has demonstrated its capability to create total aircraft, missile, and space vehicle systems. Electronics is an important part of this capability.

Over 250 Electronics Engineers and Scientists at Republic are extending parameters in communications, navigation, guidance & control, detection and data handling. A recent prime contract award has placed special emphasis on reconnaissance. As Weapon System Manager, Republic is responsible for developing this capability for its F-105D "flying electronic platform," the free world's most versatile and sophisticated manned weapon system.

Defining system requirements, conducting analytical studies, evaluating overall design, and monitoring progress of subcontractors are engineering tasks requiring broad technical knowledge and high analytical ability. Difficult problems in subsystem integration, density packaging, and reliability must be solved.

Inquiries are invited from Electronics Engineers and Physicists with experience in: Radar (front & side looking) / Infrared & Optical Systems / Antennas & Radomes / Digital Computers & Data Links / Flight & Fire Control Systems / High Speed Tape Recorders / Aerospace Ground Support Equipment.

Opportunities are at 2 Republic Locations: Farmingdale and Mineola, Long Island, N. Y.
Write to:

Mr. George R. Hickman
Technical Employment Manager
Dept. 6K
Republic Aviation Corporation
Farmingdale, Long Island, N.Y.

Mr. Paul Hartman
Technical Employment
Dept. 6K-A
Missile Systems Division
Republic Aviation Corporation
223 Jericho Turnpike
Mineola, Long Island, N.Y.

All programs are backed by the 8 laboratories of Republic's new Paul Moore Research & Development Center, the only fully integrated research complex exploring every vital aspect of the aerospace technology.

REPUBLIC AVIATION CORPORATION

An Equal Opportunity Employer

Check Inquiry Form on Page 155

DESIGN DEVELOPMENTS

For more details on the equipment, processes, and facilities described in this section,

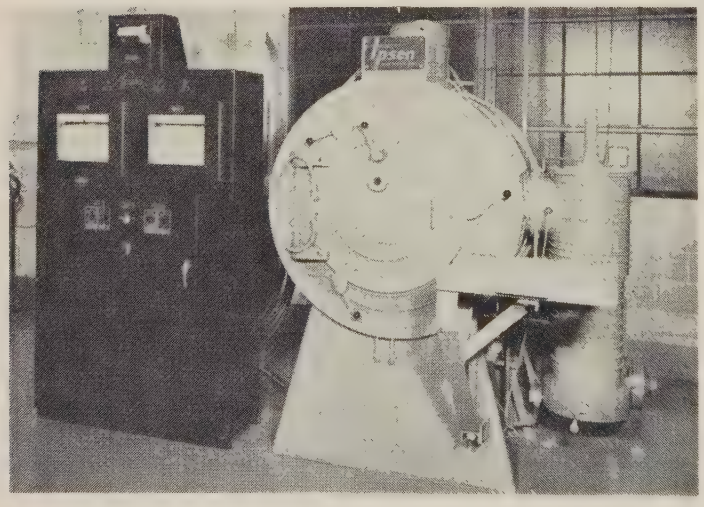
BERYLLIUM BARE-FORGED AFTER 1400-DEG-F PREHEAT

In a series of 16 trial forgings, The Beryllium Corp., Reading, Pa., and Wyman-Gordon Co., North Grafton, Mass., were able to forge unclad beryllium without using steel jackets. The process cuts production costs, say the companies, and improves mechanical properties.

Beryllium's HP-20 was used for all starting blanks. After forging, the parts were subjected to dimensional and fluorescent die penetrant inspection and underwent metallographic and mechanical property studies. The approximate mechanical properties were: ultimate tensile strength, 67,300 psi; yield strength, 0.2 per cent offset, 49,000 psi; elongation, 5.1 per cent. For the original hot pressed metal, these values were 48,100 psi, 30,700 psi, and 4.3 per cent, respectively.

Results show that blank preheat temperatures of about 1400 deg F were definitely preferable to 800 deg F in the bare-forging operation.

High-Vacuum Heat-Treat Furnace Operates up to 2400 deg F



A quick-heating and cooling vacuum furnace for hardening highspeed steels, brazing stainless steels, and annealing refractory metals and special alloys has been developed by Ipsen Industries, Inc., Rockford, Ill. With a working space of $15 \times 24 \times 10$ in., the VFC-150 can produce a maximum vacuum of 0.1 microns Hg at an operating temperature of 2400 deg F. It requires a 50-kw input and floor space of 10×12 feet.

The work load is placed in a basket on the charging platform. The operator than manually opens the door, swings the loading platform into position in front of the unit, pushes the work basket into the furnace, swings aside the platform, and seals the furnace door. Once the pre-heat and high-heat soak times are set into the control console, it is only necessary to press the start button. The rest of the operation is automatic.

The furnace uses graphite heating elements. Its welded cylindrical steel shell is water-jacketed. The open end is sealed with a water-traced front cover hinged at one side. **53**

Graphite Properties Improved by Wetting with Metal

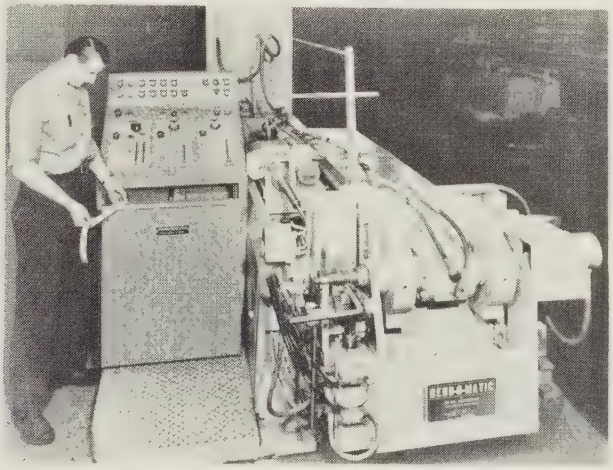
By a patented Ford process for wetting graphite with metal, iron, nickel, copper, silver, cobalt, and alloys of these materials can be combined with 10-90 per cent graphite. According to Dixon Sintaloy, Inc., Stamford, Conn., exclusive licensee under the Ford patents, the graphite-metal compositions have greatly improved mechanical and electric properties. The usual brittle characteristic of graphite is reduced greatly in some compositions and eliminated in others, says the company.

Some compositions of graphite and steel can be heat-treated by conventional method. Dixon also claims that the usual dimensional changes of graphite during the sintering cycle are reduced considerably. It says that little, if any, machining is required on finished parts. The material is malleable enough to be sized in production equipment at high speeds, even when exceptionally close tolerances are needed. **60**

Materials and Production

write in item numbers on Reader Service Card

Tape-Controlled Tube Bender Holds Close Tolerances



This automatic, numerically controlled tube bending machine reportedly produces repeat bends with absolute dimensional fidelity. According to Nu-Era Corp., 342 South St., Rochester, Minn., it can hold, bend, and twist angles to ± 3 minutes and linear dimensions to ± 0.005 in. It can handle tubing of any material up to 1¼-in. in diameter and eight feet in length.

A complete changeover from production of one combination of bending pattern, tube diameter, and radius to another can be made in 35 minutes for the average set-up. Nu-Era says that this is about one-sixth to one-eighth the time required with conventional machines. It takes but one minute to change a bending pattern on the same tube.

The Bend-O-Matic machine has a bending range of zero to 189 deg, depending on tooling. It has a three-inch maximum bending radius and a maximum bending torque of 13,200 in.-lb at 1000 psi system pressure. The complete machine, including numerical positioning and operating controls, requires 8 × 22.5 × 7 ft of floor space. **64**

WELDING KITS include accessories

Two new welding and cutting kits have been introduced by **Linde Co., Dept. S/A, 270 Park Ave., New York 17, N.Y.** Designated Heliarc "Tig-Twin" Kits, they contain all apparatus and accessories needed for most average Tig welding and cutting.

The HW-17 kit features an air-cooled torch having a continuous duty welding capacity of 130 amps. The water-cooled torch in the HW-20 kit is capable of welding at 200 amps continuous duty. Both kits include Linde's R-509 argon regulator.

No. 455 on Reader Service Card

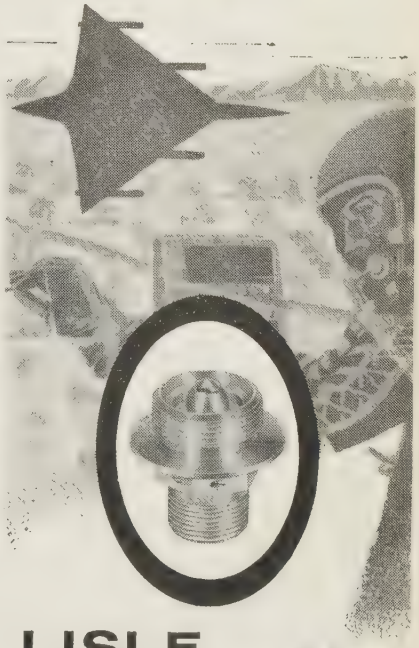
DRILL handles six units

This circuit drill is particularly suited for the production drilling of copper-clad laminated circuit boards. It will handle six stacked-drilled units or more at once, with virtually burrless holes, according to **Associated Circuit Craft, Dept. S/A, P. O. Box 1664 Glendale, Calif.** It is self-contained and, cycles automatically.

The drill features a "woodpecker" action for use with drills under 0.030 in diameter or for deep holes. Normal use of the machine involves making a stylus-template first.

No. 456 on Reader Service Card

PROTECTION AGAINST IN-FLIGHT FAILURE!



LISLE Magnetic CHIP DETECTORS

Lisle Magnetic Chip Detectors provide a constant warning system against in-flight failure when connected to a light on the Flight Engineer's or Pilot's instrument panel.

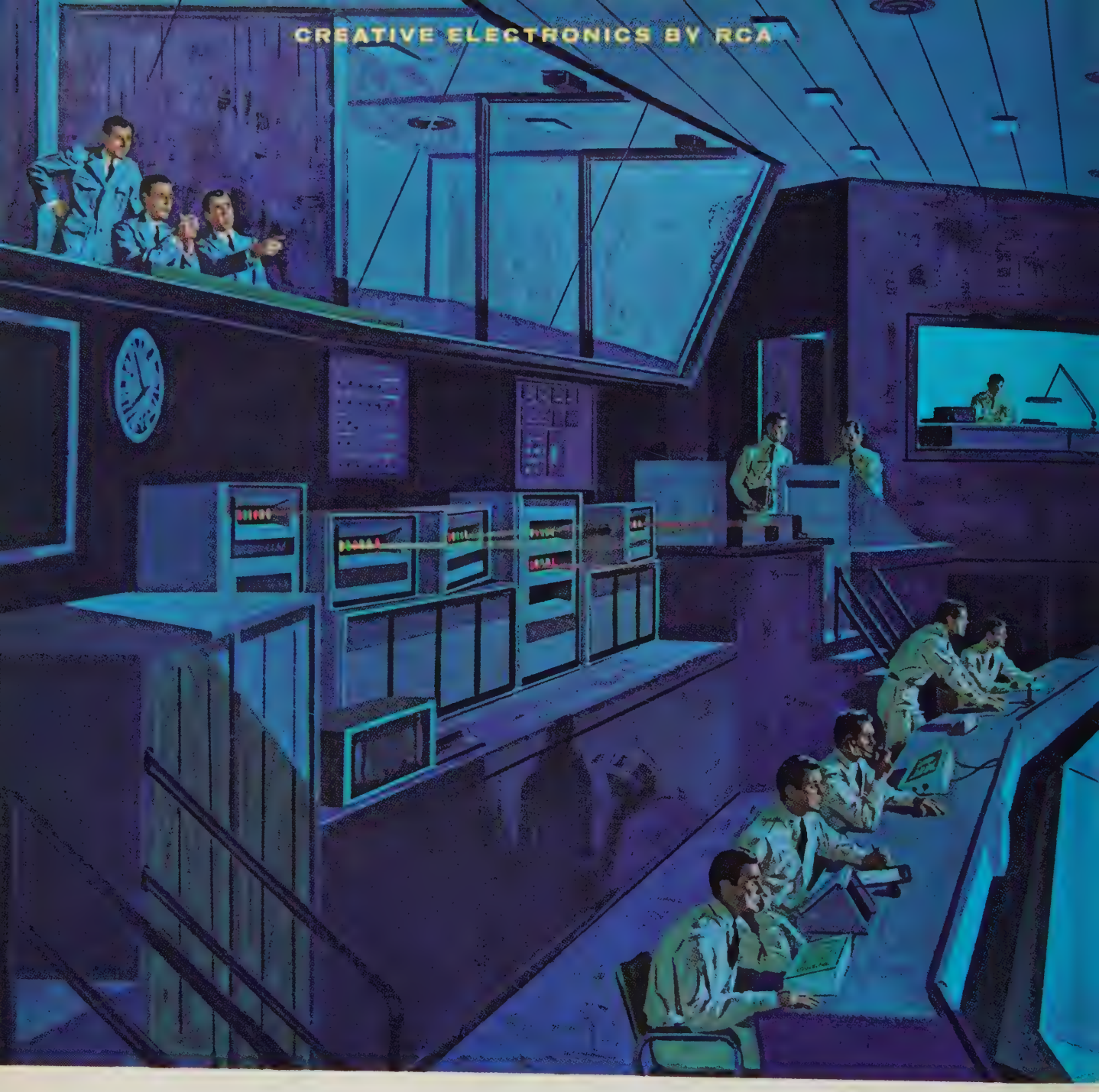
Presence of ferrous particles in the lubricant is a proven indicator of internal breakdowns. The powerful magnet in the Chip Detector picks up these particles as they appear. The particles bridge an electrically insulated gap in the Chip Detector and complete a circuit which activates the warning light.

Early detection means constant protection against in-flight failure.

Write for Catalog and Samples for Testing

LISLE CORPORATION
Clarinda, Iowa

No. 93 on Reader Service Card



NORAD ON THE ALERT

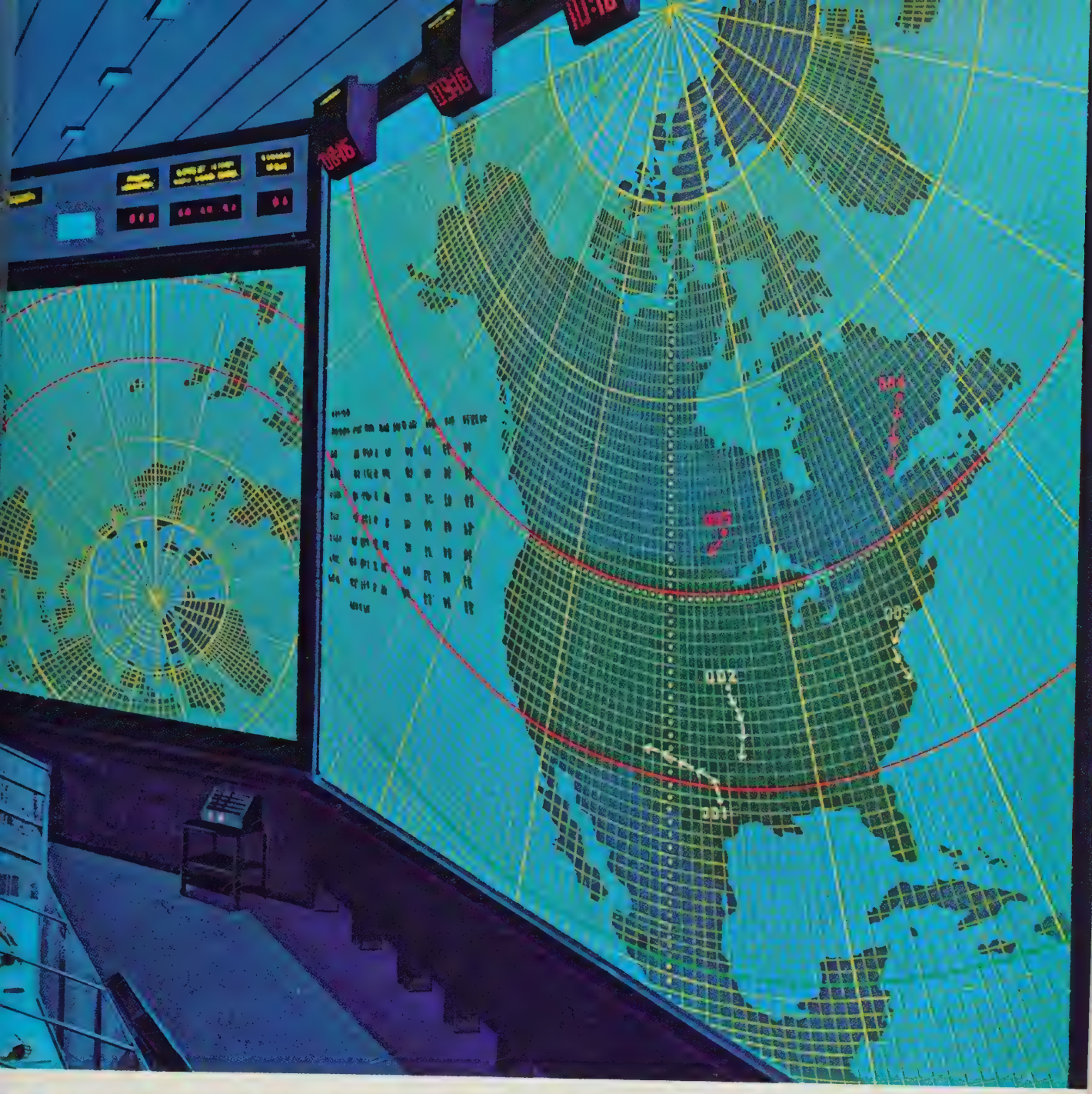
Inputs from BMEWS Provide Instantaneous Missile Data Direct to NORAD Headquarte

From our vast outer defense perimeter, over thousands of miles, to the nerve center of the North American Air Defense Command at Colorado Springs, the most advanced concept of data handling and checkout is being utilized in the BMEWS system. The stakes are high, for the purpose is defense of the North American Continent.

At BMEWS installations operated by USAF Air Defense Command, computers read out missile tracking data from giant radars. This information is simultaneously relayed to NORAD's Combat Operations Center.

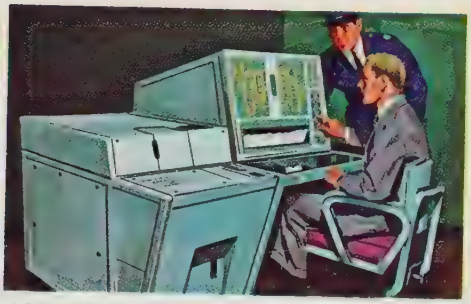
The Radio Corporation of America is prime systems contractor for BMEWS. At the COC, RCA's Display Informat Processor computing equipment automatically evaluates mis sightings, launch sites and target areas. By means of data pr essing and projection equipment installed by RCA and a team other electronics manufacturers, the findings are displayed huge, two-story high map-screens in coded color symbols, p viding the NORAD battle staff with an electronic panora of the North American and Eurasian land masses.

The handling of BMEWS inputs at NORAD is an example how RCA data processing capabilities are assuring the high gree of reliability so vital to continental defense.



AD Headquarters, RCA computing equip-
e Display Information Processor (control
shown here) receives sightings data from
and processes it for automatic readout.

RCA is prime system contractor for the sprawling BMEWS three-site radar network whose probing electronic fingers reach deep into space to provide early warning of missile attacks.



RCA's Automatic Checkout & Monitoring equipment continuously tests and checks performance of portions of the system and alerts an operator when a monitored signal exceeds certain limits

the defense needs of today a new generation of RCA electronic data
ing equipments has been born. For tomorrow's needs RCA offers one of
on's foremost capabilities in research, design, development and produc-
data processing equipment for space and missile projects. For information
e and other new RCA scientific developments, write Dept. 434, **Defense**
ic Products, Radio Corporation of America, Camden, N. J.

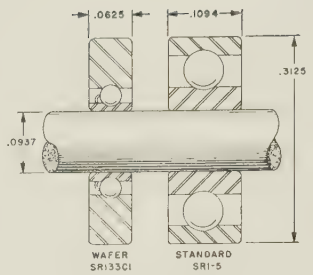
RCA

The Most Trusted Name in Electronics

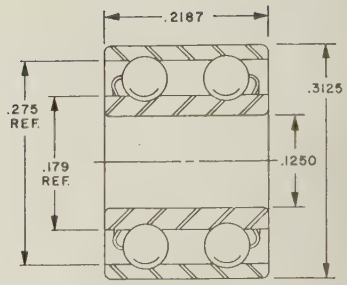
RADIO CORPORATION OF AMERICA

No. 2

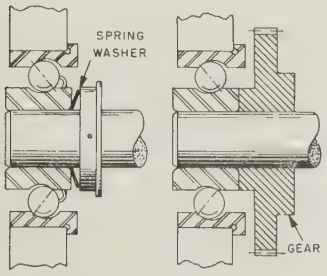
ideas you can use in working with bearings



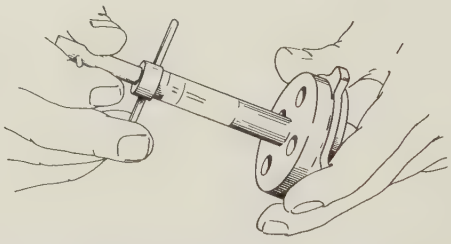
Extra-thin "wafer" bearings are ideal for use in synchros, servos, small motors, potentiometers and gear trains which require the narrowest possible bearings for any given shaft and housing diameter. The space saved by the bearings allows a shorter overall motor length; or allows more iron and copper to be added to rotors and stators without increasing overall length. A line of narrow, single-shield bearings is also available for these applications.



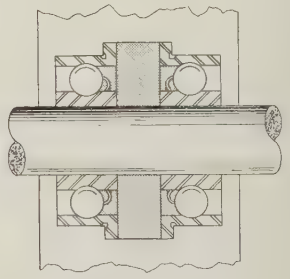
Double row bearings offer a relatively simple and economical solution to a problem found in some applications where single bearings cannot provide sufficient stability under radial loading. They provide double row stability yet can be conveniently assembled as single units. Applications include those involving cam followers, pulleys and potentiometer spindle assemblies where shaft runout is not tight. Double row bearings are available from NHBB in plain, flanged or shielded construction.



When designing servomechanism gearing for minimum backlash, the bearings should be preloaded slightly at assembly in order to remove all radial play and establish positive ball-raceway-ball contact. Two ways preloading can be accomplished are by using a spring washer against the inner race of a bearing; or by assembling a collar or gear directly against the bearing. When the design precludes preloading, a low radial play range such as .0002" to .0004" should be specified.



The most serious type of mechanical damage to precision ball bearings can occur when the bearings are being mounted on shafts or into housings. Pressure transmitted through the balls and raceways can produce permanent dents, or Brinell marks in the raceways which greatly increase bearing torque and vibration. To reduce the possibility of such damage, avoid interference fits and use special bearing mounting tools.



Here is an idea for lubricating the output shaft bearings on gear heads which will contribute toward longer bearing life: place some grease in the space between the two bearings. The grease will act as a lubricant reservoir and the oil in the grease will bleed into the bearings over a period of time. One of the greases which has a relatively high "bleedout" rate is recommended.

TYPICAL SPECIFICATIONS OF NHBB WAFER BEARINGS
(not presently cataloged)

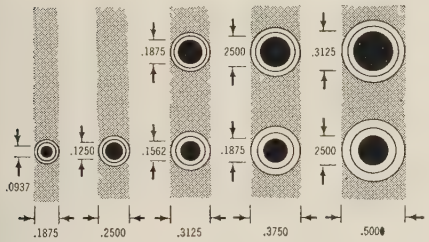
BORE	O.D.	WIDTH	WAFER NUMBER	RADIUS	C RATING
.0937	.2500	.0625	SR133C2	.005	21
.0937	.3125	.0625	SR133C1	.005	21
.1250	.5000	.1094	SR166C8	.008	82
.1250	.4250	.0937	SR144C15	.005	36
.1250	.3750	.0937	SR144C3	.005	36
.1250	.4250	.1094	SR2-5C11	.006	66
.1250	.4375	.1094	SR2-5C5	.006	66
.1250	.5000	.1094	SR2-5C7	.006	66
.1250	.4100	.1094	SR2-5C10	.006	66
.1875	.4100	.1094	SR156C9	.005	35
.1875	.5000	.1094	SR166C6	.008	82
.1875	.4375	.1094	SR156C8	.005	35
.2500	.5000	.1094	SR168C6	.008	44

150-page Design and Purchasing Manual is the most comprehensive treatise on miniature and instrument ball bearings ever published. Write for your copy — on your company letterhead, please.

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

No. 94 on Reader Service Card

more shaft per housing



These New Hampshire miniature instrument bearings have extra-large bores and permit you to increase shaft diameters without increasing bearing O.D. — to add strength yet keep center distances at a minimum. See the selection of shaft sizes available for given housing sizes:

BORE	O.D.	WIDTH	BEARING NUMBER	C RATING
.0937	.1875	.0625	SR133	21
.1250	.2500	.0937	SR144	36
.1562 .1875	.3125	.1094 .1094	SR155 SR156	35 35
.1875 .2500	.3750	.1250 .1250	SR166 SR168	82 44
.2500 .3125	.5000	.1250 .1562	SR188 SR1810	120 60

Also available flanged or double shielded or with inner rings extended or with any combination of the three. Precision standard is ABEC Class 7. Material is 440C stainless steel.

NEW HAMPSHIRE
BALL BEARINGS, INC.
PETERBOROUGH, N. H.

No. 95 on Reader Service Card

BERYLLIUM METAL for spacecraft bolts

Beryllium metal, amounting to a fourth of the weight of steel, is used in the construction of these bolts for spacecraft and missiles, according to **Standard Pressed Steel Co., Dept. S/A, Jenkintown, Pa.** Fatigue strength of the shear bolts is said to be an important feature.

Shear strength is placed by the maker at equivalent to a steel bolt, with something over 260,000 psi minimum shear values. Physical properties provide a minimum shear strength of 60,000 psi and an endurance limit of 45,000 psi.

No. 457 on Reader Service Card

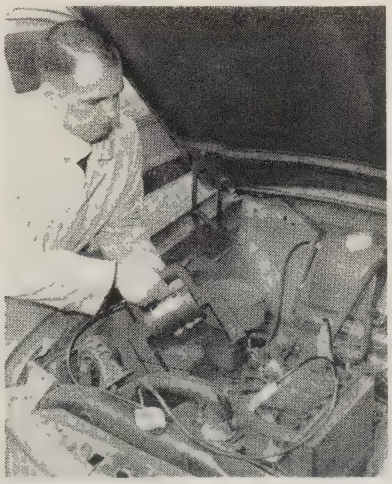
FLUXLESS SOLDER melts at low heat

This fluxless solder is said to melt at very low temperatures and eliminates the danger of metal destruction under heat. It is useable on aluminum and its alloys, zinc, tin, pewter, magnesium and other metals as well as castings, according to **Metals for Industry, Inc., Dept. S/A, 299 Pavonia Ave., Jersey City, N. J.** Called Tin-A-Lum, the product shows enough tensile strength to replace welding or brazing in many instances, says the maker.

The solder will join any dissimilar metals and is applicable on all kinds of materials with the aid of a soldering iron or a light flame and without any flux whatsoever.

No. 458 on Reader Service Card

MAGNETIC DEVICE detects flaws in metals



A portable magnetic device for detecting cracks and flaws in ferrous metals is being marketed by **Westinghouse Electric Corp., Dept. S/A, Box 2278, Pittsburgh 30, Pa.**

Developed by the United States Casting Repair Co., the unit is a U-shaped, two-pole electro-magnet. In use, the poles bridge the area to be examined. To make the flux pattern visible, a surface coating of ferromagnetic powder is sprinkled over the 72-sq-in. area that can be covered in one test. After particles over normal areas are brushed away, particles adhere to the flaw area to indicate the nature and extent of the flaw. The total unit weighs 30 lb and can be used with either 6- or 12-V storage batteries or with 110-V service.

No. 459 on Reader Service Card

MACHINE for dip-soldering

This machine enables circuit-board assemblies to be dip-soldered to acceptable military requirements. After roll-soldering or gold-plating, the etched circuit board is ready to receive electronic components, says **Associated Circuit Craft, Dept. S/A, P. O. Box 1664, Glendale, Calif.** The machine is hydraulically powered at low operating pressure.

The solder pot is 220/440 V and maintains proper temperature. A mechanically operated "skimmer" assures that the surface of solder is clean and bright.

No. 460 on Reader Service Card

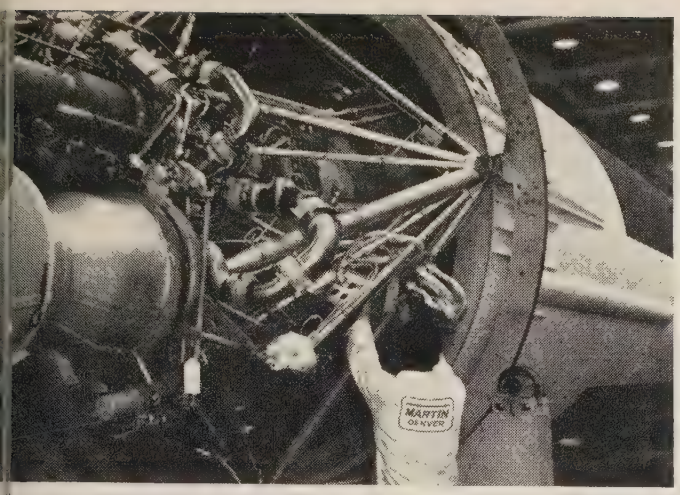
TINY SPRAY GUN weighs under a pound

This kw arc-plasma hand spray gun weighs less than a pound and makes possible the spraying of materials onto surfaces, such as small rocket nozzles, cylinders and chambers. It is less than two inches long and 1-½ in. in diameter, according to **Plasmadyne Corp., Dept. S/A, 3839 S. Main St., Santa Ana, Calif.** Operating efficiency of the gun is placed at 60 per cent, and is said to represent the conversion of electrical energy to heat.

The gun carries a 200-hour electrode life guarantee when used with argon. Other models are manufactured in 40- and 80-kw power levels.

No. 461 on Reader Service Card

Special techniques
at your command...
with TAPES FROM 3M
for the aerospace industry
"SCOTCH" AND SCOTCHFOAM" ARE TRADEMARKS OF 3M CO., ST. PAUL 6, MINN.



Lightweight heat shielding with a "Scotch" Brand Heat Reflective Tape – reflective aluminum foil laminated to glass cloth and coated with adhesive that withstands 5000° F. for short periods – shown here in the ICBM Titan's first-stage engine compartment.

All-weather preservation sealing with "Scotch" Brand Plastic Tape that stays flexible from –60° F. to +160° F. and is unaffected by most common fuels, lubricants, oils and solvents. Special adhesive sticks to any clean, dry surface – even at subfreezing temperatures.

Improved vibration control with "Scotchfoam" Damping Tape uses a unique combination of adhesive, plastic foam and reinforced vinyl backing to control resonance wherever sound and vibration pose problems – weighs 4 oz. per sq. ft. in ¼" thickness.

Faster assembly with "Scotch" Brand Riveters' Tape that holds rows of rivets for fast, neat setting. This remarkable tape is *shatterproof* – can be used in either machine or squeeze gun riveting – strips away cleanly in one piece.

Reliable masking of even the most complex contours is easy and fast with "Scotch" Brand Masking Tape. Its specially formulated adhesive sticks at a touch, prevents paint from creeping under and comes off without a trace of residue.

Other "Scotch" Brand Tapes you will find useful in air and space craft include an amazingly impervious Chemical Milling Tape, Plastic Tape for separating dissimilar metals and Heavy-Duty Protective Tape in widths up to 36". For more information, contact your 3M Representative or write: 3M Co., 900 Bush Ave., St. Paul 6, Minn., Dept. IBL 101.

SCOTCH BRAND

tapes for industry

Minnesota Mining and Manufacturing Company

...where research is the key to tomorrow

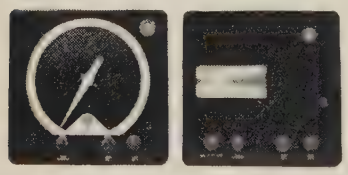
3M Company

No. 96 on Reader Service Card

NEW BLH-BUILT INSTRUMENTATION INSURES MORE ACCURATE, VERSATILE STRAIN GAGE TRANSDUCER READOUT

The complete line of mv/v instrumentation designed and built entirely by BLH now includes these new indicators for use with any strain gage transducer system.

Type 60 Digital Indicator, shown at left above, is particularly suited to load, pressure and torque systems. It provides system accuracy to ±0.25%—higher accuracies on special order. Designed for panel mounting or bench operation, it is available for fast delivery at a very reasonable cost. With the addition of this instrument, BLH now offers you a full choice of digital, disc or pointer indicators for industrial and laboratory applications.



Type 65 Automatic Calibration Indicator, middle above, is among the most accurate of all BLH instruments. This portable unit automatically reads out in pounds—is used to calibrate a variety of load measurement systems and features automatic null balance, digital readout, plus a built-in check calibrate circuit. Instrument accuracy ±0.05% of interval is standard.

Type 25 Universal Indicator can be used with any BLH load, pressure or torque transducer by simply setting a gage resistance and mv/v output dial on the front of the instrument. Manually null balanced—digital indication—transistorized, lightweight and portable. Instrument accuracy is ±0.1% of full scale. Durable Formica case.

Write for data sheets or contact your nearest BLH sales engineering representative for information and a demonstration.

BALDWIN • LIMA • HAMILTON
Electronics & Instrumentation Division
Waltham 54, Mass.

FIRST in force measurement

SR-4® Strain Gages • Transducers • Temperature Sensors • Systems

No. 97 on Reader Service Card

DAMPING TAPE for thin sheet metal

This vibration-damping tape, consisting of foam, plastic and high-tack adhesive, is designed for easy application on thin sheet metal. It reduces resonant vibration and accompanying noise by converting vibration energy into heat, according to **Minnesota Mining and Mfg. Co., Dept. S/A 900 Bush Ave., St. Paul 6, Minn.** It is available in six-inch widths up to eight feet.

Caliper of the tape is 0.250 in., weight is 0.250 lb/sq ft. A single layer is designed to provide excellent damping on steel and aluminum as thick as 0.060 in.

No. 462 on Reader Service Card

STRIP ALLOYING aids transistor reliability

A strip alloying production technique is credited with improving the reliability of silicon transistors. **Philco Corp., Dept. S/A, Lansdale, Pa.,** announces that this medium-frequency silicon transistor is one of a series of models to be produced by this process. The company says these transistors will feature high beta, very low saturation voltage, and high emitter base diode voltage ratings.

Philco states that strip alloying permits the diode voltage and beta to be measured accurately during manufacture. The result is reported to be greater uniformity and parameter control.

No. 463 on Reader Service Card

SULPHIDES for heat conversion

A group of high-temperature thermoelectric materials that permit the direct conversion of heat into electricity has been announced by **Westinghouse Electric Corp., Dept. S/A, Box 2278, Pittsburgh 30, Pa.** They are said to permit conversion at temperatures considerably above the melting point of copper.

The materials are varieties of two compounds, samarium sulphide and cerium sulfide, and are refractory materials having excellent high-temperature stability and good thermoelectric efficiencies at temperatures as high as 2000 deg F, it was stated.

No. 464 on Reader Service Card

65 PUROLATOR FILTERS protect the fluid systems of these commercial jets. Purolator filters are part of the design of practically every major jet in flight today – military as well as commercial.

Purolator filters fly with all the big new jets

long-range research enables Purolator to anticipate the specialized needs of the aircraft and missile industry

Practically every major jet aircraft today — military as well as commercial—incorporates Purolator filters into its design. Purolator filters also protect the fluid systems of such missiles as the Polaris, Jupiter, Hawk, Atlas, Terrier, Thor and Hound Dog.

Long-range research enables Purolator to anticipate — and meet — the exacting needs of the aircraft and missile industry. During the 50's alone, Purolator invested nearly $7 million in engineering research and development . . . now operates the nation's newest, most-advanced filtration research center at Rahway, New Jersey.

Following are just three examples of how Purolator research and engineering skill succeeded in fulfilling some unusual aircraft and missile filter design requirements.

FREEDOM FROM BUILT-IN CONTAMINATION. In order to eliminate contamination possibilities afforded by conventional welding, brazing, or cementing, Purolator designed a filter for the hydraulic systems of Lockheed Electras and F-104G jets in which the filter element, caps and center tubes were *pressure-locked* together.

The filter element is composed of 20 square inches of convoluted stainless steel wire cloth. Flow capacity: 4 GPM. Nominal filtration: 10 microns. Maximum differential across assembly: 10 psi.

ABILITY TO OPERATE UNDER PRESSURE AND TEMPERATURE EXTREMES. A Purolator jet fuel filter used by Boeing's B52-G bomber and KC-135 airborne tanker is expressly designed to operate efficiently at extremely high altitudes and in a temperature range of –65°F. to plus 250°F.

The convoluted stainless steel wire cloth filter element contains 360 square inches of filtering area. A magnetized spring action differential indicator shows when the element becomes clogged and pressure drop across the element increases to a pre-determined figure.

MINIATURIZATION. This design requirement is well illustrated by a Purolator filter used in the hydraulic system of the Hawk missile.

The filter measures only 1" x $\frac{9}{16}$". Weighs one ounce. Yet it has a flow capacity of 2 GPM. The wire cloth filter element contains nearly 1,000 feet of stainless steel wire and is convoluted to give 4.2 square inches of filtration area. Nominal filtration: 10 microns. Maximum operating pressure: 2,500 psi. Proof pressure: 3,750 psi.

Filtration requirements of aircraft, missile and other highly-technical industries are becoming increasingly specialized and demanding. New filter media today provide degrees of filtration to 0.3 microns — where 10 microns was considered the ultimate a decade ago.

If you have an unusual filtration application, write us about it. As the world's largest, most-experienced manufacturer of filters, Purolator has the research, engineering, and manufacturing facilities to help solve your problem.

Filtration for Every Known Fluid **PUROLATOR**

PRODUCTS, INC.

Rahway, New Jersey and Toronto, Canada

No. 98 on Reader Service Card

NEW MAGNETIC HOLD-IN SWITCH

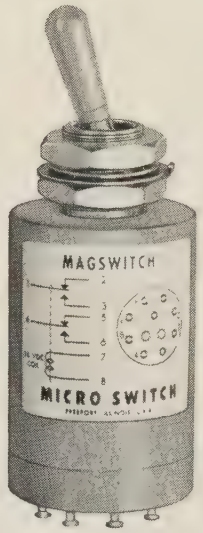
Switch circuit is closed by operation of the spring-loaded toggle lever.

When solenoid is energized, toggle lever stays in operated position, circuit remains closed.

"5ET" SERIES SWITCHES

THE "ET" SERIES includes models with either double-pole double-throw or single-pole double-throw circuitry. Turret type solder terminals are available for easy, wrap-around connections. "ET" Switches are also available with sealed lead wires extending at a 90° angle from the base. Where safety requires, a pull-to-unlock lever is available which is locked out of momentary position.

PERMITS REMOTE ELECTRICAL RELEASE



"6ET"—ACTUAL SIZE

THE NEW "6ET" MAGSWITCH* is a sealed momentary-action toggle switch with a built-in solenoid. When the solenoid is energized, actuation of the toggle lever holds the switch in operating (maintained) condition. Breaking the solenoid circuit (usually done remotely) releases the solenoid-held lever, converting the switch from maintained to momentary condition. Release can also be accomplished by manually overriding the toggle lever.

The precision, double-pole double-throw switching unit and solenoid are contained in one compact unit. The "6ET" measures approximately 2¼" behind the panel and one inch in diameter. This switch requires no auxiliary relays as do other remotely controlled switches—another saving in space.

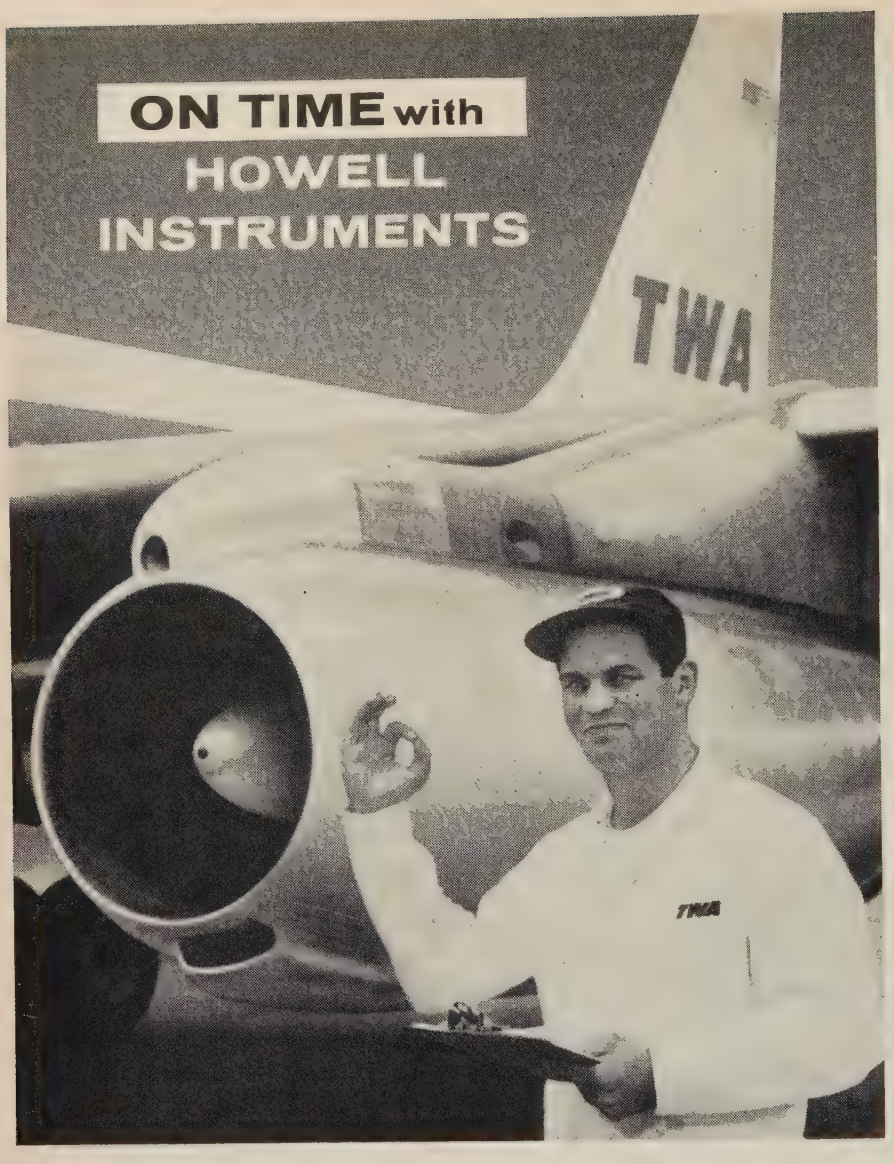
Switching unit and solenoid are sealed within an enclosure which has been evacuated and filled with inert gas under pressure, which insures reliable operation, regardless of changes in atmospheric conditions. An elastomer seal at the base of the toggle lever prevents entry of dust or moisture. The "6ET" meets immersion test requirements of MIL-E-5272, procedure 1. See the Yellow Pages for the nearby MICRO SWITCH Branch Office or write for Data Sheet No. 121.

**Trademark*

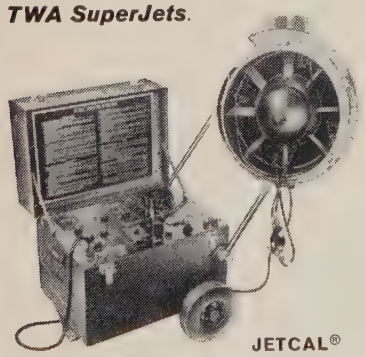
MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls, Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH Precision Switches

No. 99 on Reader Service Card



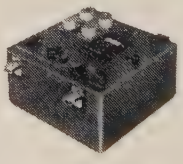
● We at Howell Instruments, Inc. are proud of the part our jet test equipment has played in TWA's exemplary record of on-schedule service. Here shown is HOWELL equipment used by their capable maintenance crews on ***TWA SuperJets***.



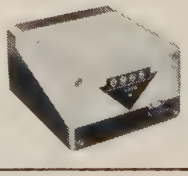
JETCAL® Analyzer

Tests EGT system accuracy to ±4°C *(functionally, without running the engines!)* Runs temperature spread check on two engines at same time. Cuts test time 50%. Tests RPM accuracy to 10 RPM in 10,000 RPM (±0.1%). Checks Heat, Anti-Ice and Fire Detection Systems.

BH4101
TEMPERATURE SPREAD TESTER
Determines spread temperature in engines and verifies accuracy of cock-pit indicators.



BH170A
AUTOTAK®
Indicates % RPM to 0.1% for fine adjustment of engine trim.



ENGINE TRIM CHECKER H208-2
We are now introducing this Engine Trim Checker which combines the features of the Auto-Tak and Temperature Spread Tester . . . with the added feature of reading PT7 pressure. All presentations are digital (automatically null balanced) to ±0.1% indicator accuracy. A universal tester suitable for all jet engine trim operations . . . and all in a case smaller than ½-cubic-foot!

HOWELL INSTRUMENTS, INC.
FORMERLY B&H INSTRUMENT CO., INC.
3479 WEST VICKERY BLVD. • FORT WORTH 7, TEXAS

IMAGE AMPLIFIER uses gamma rays

A new gamma ray image intensifier system that detects minute flaws in four-in.-thick steel and other dense objects has been announced jointly by **The Rauland Corp., Dept. S/A, Chicago, Ill.**, and **Picker X-Ray Corp., Dept. S/A, Cleveland, Ohio.**

The new intensifier tube in the system permits continuous inspection of materials which previously could only be inspected by gamma ray photographs. With the system, an operator can watch a TV screen as specimens move along a conveyer, and determine the exact location of each defect. Potential applications are in nuclear reactors to observe the passage of molten metals through pumps and pipes and for the inspection of metal objects too dense for X-ray study.

No. 465 on Reader Service Card

SWIVEL FITTINGS provide low torque

This low torque swivel unit offers universal application in fluid line systems and can be used with almost any type of flow media. **Dozier Eastman & Co., Dept. S/A, 401 Silver Lake Blvd., Los Angeles 26, Calif.,** reports that it provides 360 deg rotation, with an operating capability up to 5000 psi.

The fitting is pressure balanced and hence not subject to separation forces. The line is available from ⅛ to 2 in. od. The ¼-in. tube has torque of less than ¾ inch-pounds at 3000 psi; the 1-in. tube has a torque of less than 4 inch-pounds at 3000 psi.

No. 466 on Reader Service Card

ONE-STEP CLEANER for pre-paint treatment

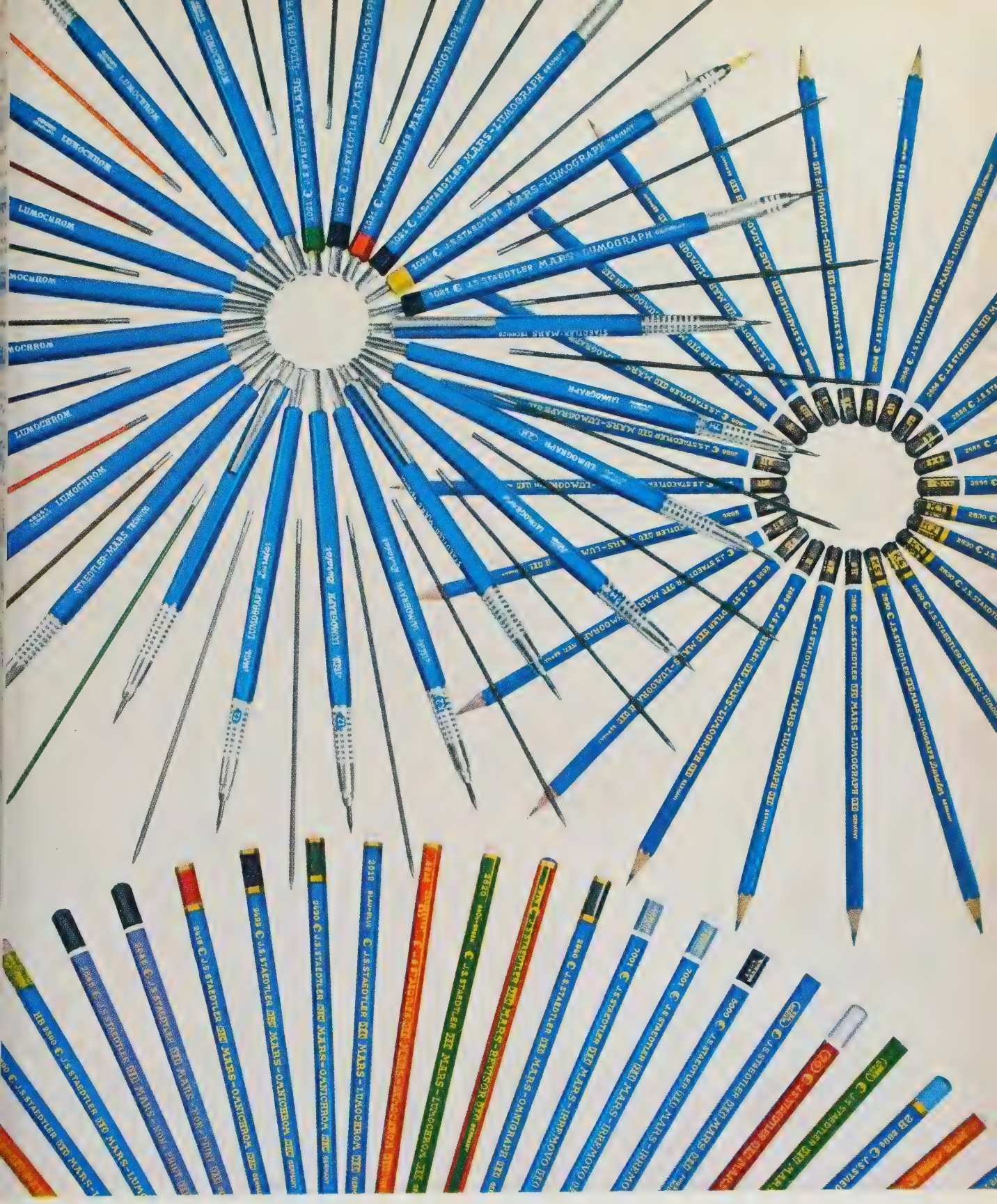
A one-step cleaner designed to simplify the pre-paint treatment of metal surfaces has been announced by **Turco Products, Inc., Dept. S/A, 24600 S. Main St., Wilmington, Calif.** It is said to simultaneously clean, passivate and remove corrosion.

The product can be applied by brushing, spraying or swabbing, and is said to be applicable for wing sections, fuselages, assembled planes, or construction machinery and tractors without use of special equipment.

No. 467 on Reader Service Card

No. 100 on Reader Service Card

No. 166 on Reader Service Card



ALL MARS – ALL TOPS

.... all imported from West Germany, made to meet the highest standards of professionals.

the pencil that's as good as it looks

MARS

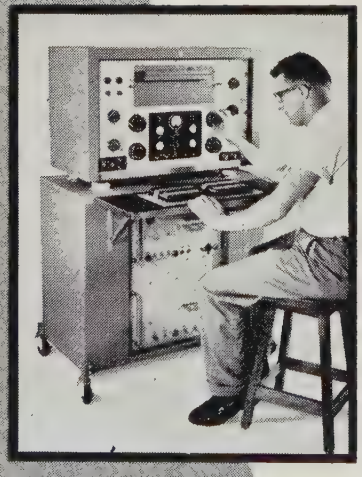
J.S. STAEDTLER, INC.
HACKENSACK, NEW JERSEY

Mars products are available at better engineering and drafting material suppliers everywhere.

AC-DC INSTRUMENT CALIBRATION to 0.25% Accuracy

Model 829A provides a single package method of maintaining plant-wide instrument accuracy at modest cost.

Full-scale calibration accuracy of 0.25% for both AC and DC meters over ranges from 0.25 millivolt to 2000 volts and 2 microamperes to 20 amperes is provided by this completely self-contained unit. AC calibrations can be performed from 50 to 400 cps., depending on line frequency used, or the Model 829A can be driven by an optional variable frequency power supply (see below).



The Model 829A is a comparison type calibrator, using horizontally mounted standard meters of high accuracy and dependability. Range switches and high voltage discharge circuits are safety interlocked, protecting the standard meters and the meter being tested from accidental overloading. Model 829A can be used effectively and safely by personnel not previously acquainted with instrument calibration techniques. Net price $3,150.

The most compact calibration system available is also mobile.

Photo inset shows the Model 829A secured with shock mounts on the RFL Model 10 Test Equipment Cart with the standard meters recessed into a drop-leaf work shelf. In the Cart is a Model 500 Variable Frequency Power Supply for line regulation and for supplying any frequency for calibration from 50 to 400 cps.

Performance is rigidly guaranteed. Prices are f.o.b. Boonton, N.J. and subject to change without notice.

SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

Radio Frequency LABORATORIES, INC. Boonton, New Jersey, U.S.A.

MULTI-CONTACT CONNECTOR for extreme environments

This multi-contact connector is immersion resistant, and is designed to withstand 50 hours of salt spray, a 50 g shock, and a temperature of 500 deg F for 1000 hours, says the **Electro Mechanical Instrument Div., Consolidated Electrodynamics Corp., Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif.** The connector will handle 1500-volt rms potentials at sea level.

Designed to meet specification MIL-C-26500, the new connector is available in 24-, 31-, or 55-contact sizes. Separate snap-in pins and sockets meet the requirements of MIL specifications NS 26636 for size and materials.

No. 469 on Reader Service Card

BEARING uses nylon retainer

This type NJ needle thrust bearing uses a glass fiber filled nylon retainer that reduces undesirable sliding friction, says **The Kaydon Engineering Corp., Dept. S/A, Muskegon, Mich.** This injection molded retainer incorporates low friction, light weight, and features non-magnetic and noise dampening features.

Thrust capacity is reported to be equal to or greater than that of all steel bearings—and operating speeds are reported greater. It operates at a lower temperature than steel bearings, having lower heat conductivity and less heat generation. Diameters of needles have been standardized at 0.078 in. for the entire line. It can be producted in infinite combinations of bore and outside diameter sizes.

No. 470 on Reader Service Card

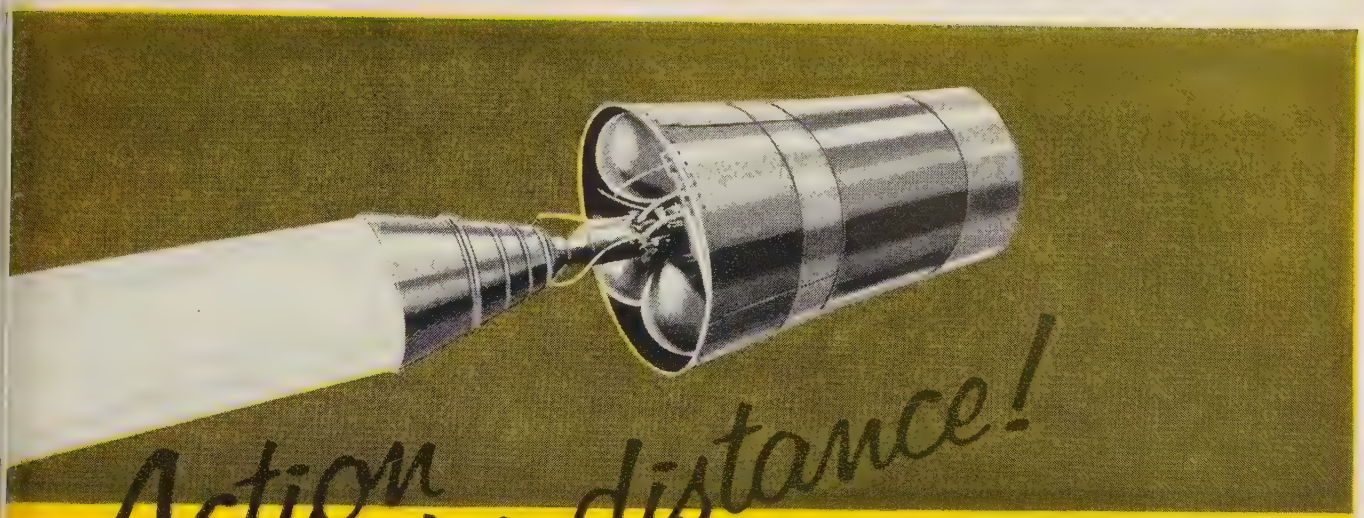
SHOCK MOUNTS simplify tooling

Elastomeric shock mounts with a guaranteed ±10 per cent spring rate are offered by **Lyon Aircraft Services, Dept. S/A, Burbank, Calif.**

The mounts are dimensionally designed to simplify mounting designs and tooling and to provide a semi-standardization in the selection of auxiliary mounting hardware, such as base legs, suspension legs, and frames. They are bolted, with no studs required. Cure dates are shown on the elastomer. Two standard sizes are available for immediate delivery.

No. 471 on Reader Service Card

No. 102 on Reader Service Card



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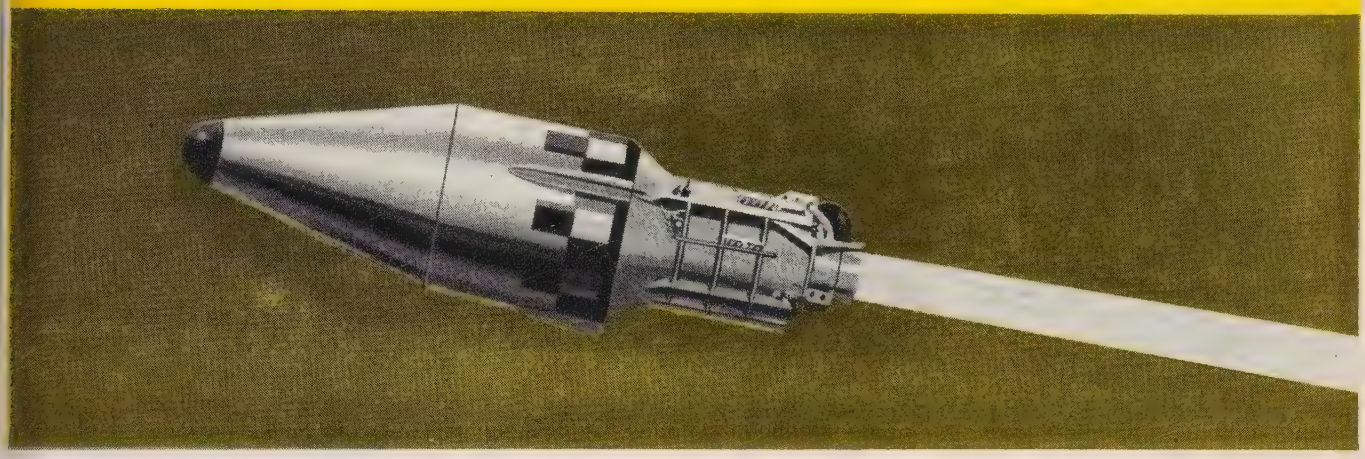

There are no launching crews or support equipment miles above the earth's surface where AbleStar and Agena-B begin their crucial missions. Yet out of a combined total of 52 opportunities to perform, from initial flight tests through 12 July 1961, these advanced upper stages and their earlier configurations have racked up at least 44 unqualified successes with only 4 known failures involving their propulsion systems.

These powerful, versatile liquid-fuel vehicles, mated with rugged Thor and Atlas boosters, have led the race for space with an impressive array of firsts. An AbleStar was the first rocket engine to be successfully restarted in space and a predecessor Able helped send the first re-entry vehicle over full intercontinental distance. The Agena vehicles were the first to put U.S. orbital payloads into the thousand-pound class and the first to send capsules back to earth from orbit. Together, they have helped orbit no less than 39 of the 48 U.S. satellites!

Both are reliable, restartable and applicable to a variety of space missions. Both use Dimazine in their bi-propellant main propulsion systems.

Dimazine provides a near-ideal combination of physical and chemical properties for rocket applications. It is remarkably stable to heat, contamination (catalytic decomposition) and shock. Its non-corrosiveness, low freezing point, storability and ease of handling minimize the complexities of pre-firing operations. It has excellent characteristics of ignition, combustion, fluid-flow and cooling. Density, liquid range and vapor pressure are also favorable.

Dimazine can be used with a variety of storable and higher-energy cryogenic oxidants. Fast expandability of production, to meet new and larger requirements with increasingly favorable supply economics, has been repeatedly demonstrated.

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No. 103 on Reader Service Card

JOURNAL BUSHINGS feature plastic insert

A new line of self-lubricating journal bushings capable of dynamic loads to 25,000 psi and static yield loads to 50,000 psi at low rotational speed without damage is now being offered by **Southwest Products Co., Dept. S/A, 1705 So. Mountain Ave., Monrovia, Calif.**

The bushings use stainless steel housings with a plastic alloy insert made of a material called Dylon. It is reported by the company that the life of these bushings is practically unlimited at unit loading of 10,000 psi or less. At high loading, it is claimed that no galling, fretting, nor brinelling occurs.

No. 251 on Reader Service Card

DATA FILE

SCREWS—The Unbrako KS 812 Series of high strength, stainless steel socket head cap screws is presented in a four-page technical bulletin from **Standard Pressed Steel Co., Dept. S/A, Jenkintown, Pa.** The booklet, Form 2734, gives specifications and performance data, mechanical properties and dimensional information, and reviews possible applications.

No. 252 on Reader Service Card

STEEL BARS—A case study portfolio from **La Salle Steel Co., Dept. S/A, P.O. Box 6800-A, Chicago 80, Ill.,** compares the company's "Fatigue-Proof" steel bars in machinability and tool life with the materials they commonly replace. Designated Case Study Portfolio No. 3, it gives 11 case studies for specific parts applications.

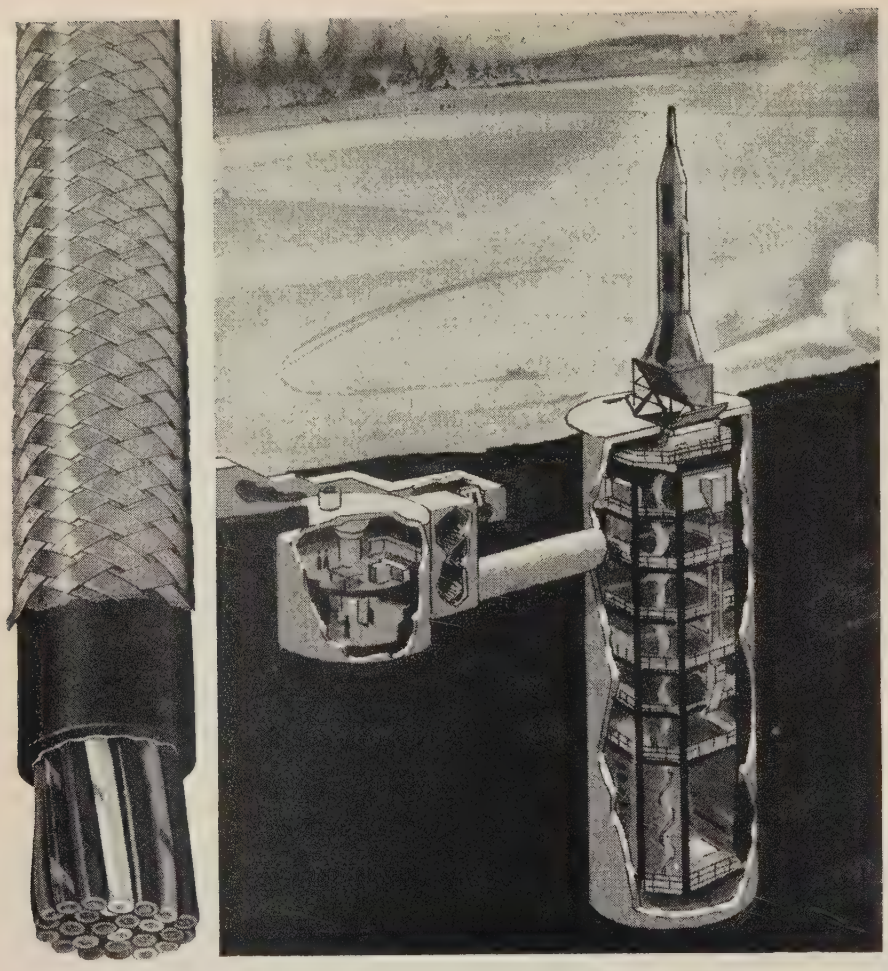
No. 253 on Reader Service Card

CONTAINERS — A booklet on glass filament wound container structures for missiles and engines is available from **Minnesota Mining and Mfg. Co., Zenith Plastics Div., Dept. S/A, 1600 W. 135th St., Gardena, Calif.** It is illustrated with photographs and graphs.

No. 254 on Reader Service Card

METAL POWDERS — Technical Data Sheet T-3 from **Wall Colmonoy Corp., Dept. S/A, 19345 John R St., Detroit 3, Mich.,** discusses selection of metal powders for sprayed overlays. Both standard metallizing procedure and the Sprayweld process are covered.

No. 255 on Reader Servce Card



Rockbestos Ground Support Cable Selected for Titan Silos

Rockbestos ground support cable is designed to meet rigid specifications for reliability, flexibility, resistance to high and low temperatures and to the destructive effects of missile fuels.

Rockbestos ground support cable meets and conforms to all requirements of MIL-C-13777-C.

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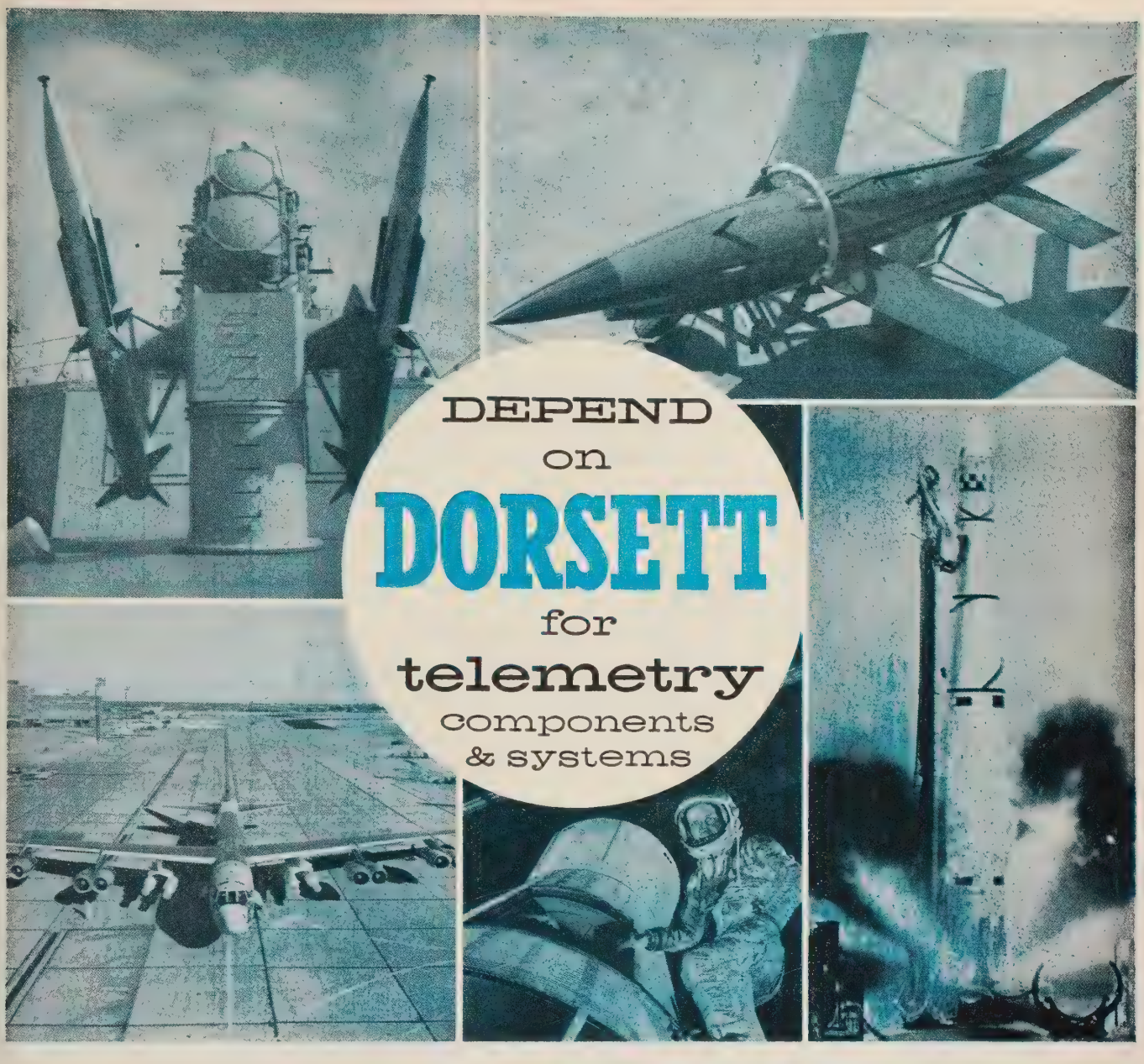

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No. 105 on Reader Service Card

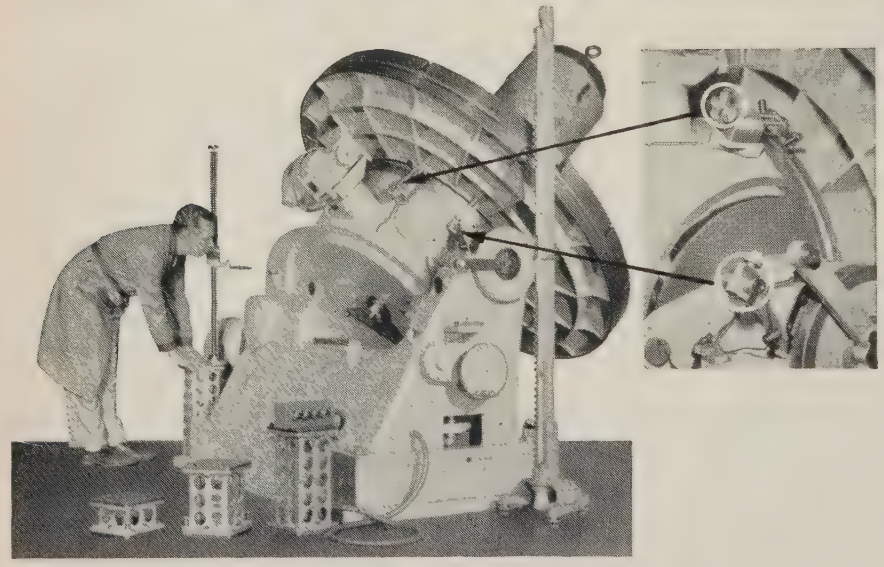
TITANIUM – Sintered titanium as a design material is the subject of Bulletin 100 from **Clevite Corp., Mechanical Research Div., Dept. S/A, 540 E. 105th St., Cleveland 8, Ohio.** The four-page folder presents basic design information and properties for Clevite sintered titanium, including tolerances, processing and specifying data, and technical service information.

No. 256 on Reader Service Card

STAINLESS STEEL—A 32-page booklet on precipitation hardenable stainless steels has been issued by **Republic Steel Corp., Dept. S/A, 1441 Republic Bldg., Cleveland 1, Ohio.** The booklet, Adv. 1223, explains what precipitation hardening is and how it is accomplished, and gives data on heat treatments, mechanical properties, and fabrication for Republic's four PH types.

No. 257 on Reader Service Card

THROUGH THESE MICROSCOPES . . .



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Rotary table positioning with 5 second accuracy? Amazing! And when you recall that there are 1,296,000 seconds in any circle, 5 second accuracy is indeed amazing, but *true* . . . with ROTAB tiltable rotary tables. For by incorporating optical measuring systems into ROTAB design, full 360° radial positioning, 90° angular settings are easily achieved with this fine degree of precision . . . and repeat settings within one second of arc are standard procedure!

Microscopic accuracy is just one unique ROTAB feature. In addition, motor powered rotating and tilting, easy-to-use portable controls, horizontal loading vastly improve efficiency . . . to a point, in fact, where 50% savings in set-up time *alone* are not unusual. You can use ROTAB, moreover, for inspection and quality control operations or for tool room machining. In a nutshell, ROTAB gives you precision positioning, cost-cutting efficiency and a wide range of application versatility. Ask about ROTAB today!

FREE! Catalog containing detailed information on complete ROTAB line, from 12″ to 84″ faceplate sizes. Yours for the asking . . . write today.

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No. 106 on Reader Service Card

WIRE-MARKING MACHINE—Three models of wire and tube marking machines are covered in a bulletin issued by **Kingsley Machine Co., Dept. S/A, 850 Cahuenga Blvd., Hollywood 38, Calif.** The advantages of letter-numeral coding are also covered in the literature.

No. 258 on Reader Service Card

RINGS—Rolled steel rings manufactured by **Edgewater Steel Co., Pittsburgh 30, Penna.,** are discussed in their 12-page, highly-illustrated brochure. The Edgewater process is described, with details on the steels used, finishing operations, quality control, and final inspection.

No. 259 on Reader Service Card

POLYCARBONATE RESIN – A four-page folder listing sources of supply for Lexan polycarbonate resin in standard fabricated shapes is available from **General Electric Co., Dept. S/A, Pittsfield, Mass.** Designated CDC-389, it lists fabricators, and sizes of rods, sheet, tube, film and slab. It also contains a description of the 14 properties of Lexan resin.

No. 260 on Reader Service Card

CLEANING CHEMICALS—A 14-page booklet describing ultrasonic cleaning techniques has been issued by **Branson Instruments, Inc., Dept. S/A, 40 Brown House Rd., Stamford, Conn.** It gives information on physical properties of cleaning chemicals, suggests applications and procedures.

No. 261 on Reader Service Card

FASTENERS – General characteristics and physical properties of bolts, nuts, screws, dowels, and miniature internal wrenching bolts for high-temperature use are given in Engineering Data Catalog No. 286 from **Mercury Air Parts Co., Inc., Dept. S/A, 9310 W. Jefferson Blvd., Culver City, Calif.** The catalog is illustrated with engineering prints.

No. 262 on Reader Service Card

ALLOYS—Data sheets on four beryllium copper alloy strip products are available from the **Brush Beryllium Co., Dept. S/A, 5209 Euclid Ave., Cleveland 3, Ohio.** They show physical and mechanical properties, and describe methods of heat treating, forming, joining, and plating of two high-strength and two high-conductivity products.

No. 263 on Reader Service Card

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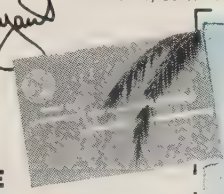
You have my personal assurance of a sunny business climate here in Florida. You have positive assurance of every aid and assistance possible from our Florida Development Commission and from the overwhelming majority of our businessmen, industrialists, and financiers. We have everything to make your large or small enterprise healthy and successful. Write, wire or phone us today. The only thing better than a FLORIDA vacation is having your plant here."

Governor, State of Florida

FLORIDA FOR CONVENTIONS — Write for free information on Florida's wonderful facilities for your group meeting.



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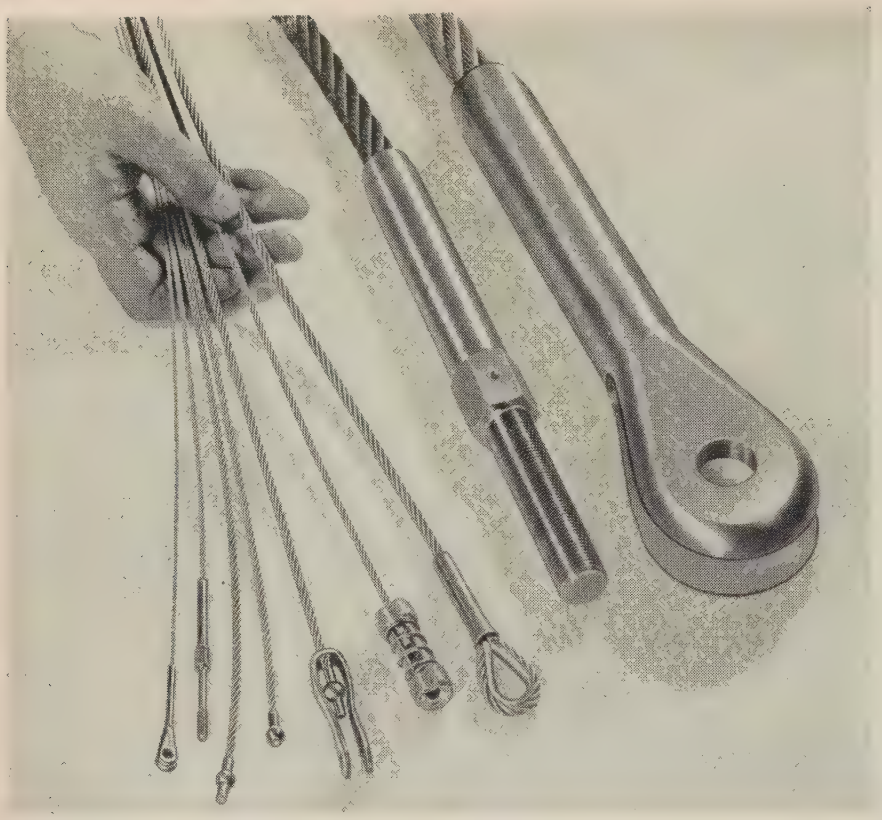

Tru-Loc Swaged Aircraft Fittings

guaranteed free from defects...

Tru-Loc aircraft fittings are guaranteed three ways—they conform to specified dimensions; they hold to the minimum rated breaking strengths of the cables to which they are swaged; and they are free from deformation, splits and internal cracks. With Tru-Loc swaged fittings you also get:

Widest range of sizes • Tru-Loc fittings are available for cables ranging from 1/16″ to 2 1/2″ diameters.

Types for every application • Sleeve-type, ball-type, ball-with-strap, center-pull loop fittings, "*Quickies*" for instant connect and disconnect—all of these fittings were originated by American Chain & Cable Company, Inc. Special fittings can be designed as required.

"NO-MAG" CABLES GIVE BETTER CORROSION-RESISTANCE THAN STAINLESS STEEL "No-Mag" cable is non-magnetic, won't interfere with instrument operation. In corrosion-resistance and thermal characteristics, it is superior to standard stainless steel. "No-Mag" aircraft cables also offer high fatigue and abrasion resistance, are available in a complete range of sizes in all the standard aircraft constructions.

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NICKEL ALLOYS — Technical Data Sheet T-1 discussing corrosion resistance of Colomoy nickel alloys is available from **Wall Colmonoy Corp., Dept. S/A, 19345 John R St., Detroit 3, Mich.** The sheet lists corrosive media in which the alloys are generally resistant. A bar chart plots corrosion resistance of Colomoy No. 6 versus 18-8 stainless steel in various acids.

No. 264 on Reader Service Card

LUBRICATION — Description, properties, and application of Drilube 822 are given in a technical bulletin published by **Drilube Co., Dept. S/A, 723 W. Broadway, Glendale 4, Calif.** Additional information on this nondrying, insoluble lubricant includes packaging, handling, and price.

No. 265 on Reader Service Card

EXPANDED METALS — A four-page brochure published by **Exmet Corp., Dept. S/A, 127 Marbledale Rd., Tuckahoe, N.Y.,** discusses light gauge fine expanded metal. Materials and manufacturing techniques are presented.

No. 266 on Reader Service Card

BALLS—A new publication has been issued by **SKF Industries, Inc., Dept. S/A, Front & Erie, Philadelphia 32, Pa.** It gives data on material, hardness, grades, tolerance, corrosion resistance, uses, and magnetic properties of various types of steel, brass, and bronze balls. One section of the book covers methods of measuring and testing balls, a second gives hardness conversion tables, and a third gives definitions and nomenclature.

No. 267 on Reader Service Card

BEARINGS — An illustrated 64-page catalog has been issued by **Miniature Precision Bearings, Inc., Dept. S/A, Precision Park, Keene, N.H.** In addition to providing dimension data on various types of bearings, it includes such topics as nomenclature, bearing selection, loading, fits, applications, failure analysis, handling and installation, and cleaning and lubrication.

No. 268 on Reader Service Card

TUBING — A six-page pamphlet on hot-rolled carbon steel hollow structural tubing is available from **National Tube Div., United States Steel, Dept. S/A, 525 William Penn Place, Pittsburgh 30, Pa.** The pamphlet includes specification data on square tubing from 1x1 to 10x10 and on rectangular tubing from 2x3 to 6x10.

No. 269 on Reader Service Card

No. 108 on Reader Service Card

America's FIRST two-man space team will rely on a Honeywell designed and developed inertial navigation and flight control system for controlling their space craft. The work we are doing on Project Dyna Soar is representative of the many advanced systems that are being evolved and developed into working hardware at Honeywell. It is typical of the creative concepts that pose challenges to the engineer or scientist possessing imagination, drive and talent.

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Increased activity in the design and development of advanced stabilization and reference systems has created these select, high-level professional openings in the Aero Division of the Honeywell Military Products Group.

Physicists—For experimental research and development program in solid state materials and processes for high accuracy inertial instruments. Areas of investigation include the following: stability of materials in the micro-strain region, deposition of metallic coatings, ultra-precision gauging, shaping and surface finishing techniques, and voltage breakdown phenomena in high vacuum.

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Sr. Systems Analyst—Experience in analysis of aircraft stability and control. Familiar with both analog and digital computers and capable of applying various types of stability criteria such as phase amptitude plots, root locus, etc.

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Microelectronic Engineer—Experience in the basic development of micro-miniature devices or design of one or more types of electronic components such as semiconductors or resistors.

Reliability Engineer—Determination and application of reliability techniques on components and systems. Knowledge of basic electronic circuits and reliability concepts such as prediction, derating, parameter variations and redundancy.

Send your resume stating your areas of interest, or request for further information to: Mr. Roy Richardson, Technical Director, Aeronautical Division, 2676 Ridgway Road, Minneapolis 40, Minn.

To explore professional opportunities in other Honeywell operations, coast to coast, send your application in confidence to: Mr. H. D. Eckstrom, Honeywell, Minneapolis 8, Minnesota.

An Equal Opportunity Employer

Check Inquiry Form on Page 155

DESIGN DEVELOPMENTS

For more details on the equipment, processes, and facilities described in this section, write in item nun

SPACECRAFT STAR TRACKER USES MAP-MATCHING

A star field tracker that will weigh less than 50 lb in its final form has been developed by The Martin Co., Baltimore 3, Md., as part of a feasibility study of the Apollo moon-orbiting vehicle. It is designed to provide reliable guidance and orientation of spacecraft in flight.

Space navigation systems developed in recent years have generally employed the sextant principle, which gives a two-dimensional star fix. Since the problem of navigation in space is three-dimensional, previous systems have required continuously coordinated star fixes.

The Martin star tracker simplifies the three-dimensional problem by map-matching against a pattern of stars. Once a field or constellation has been chosen as a reference, the tracker determines the vehicle's orientation and produces the necessary output to provide proper guidance. Using the same map-matching techniques, the instrument can follow approaching lunar contours and guide a spacecraft to a pre-selected launching point on the moon.

Tri-Axial Accelerometer Senses ±1 to ±50 g

A potentiometer-type accelerometer has been developed by the Instrument Div., Bourns, Inc., 6135 Magnolia Ave., Riverside, Calif., to provide a high-level signal output proportional to a component's acceleration. The signals are produced, respectively, by each sensing axis.

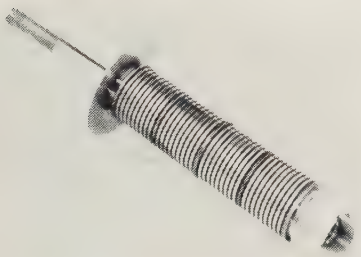
Fluid-damped and hermetically sealed Model 620 meets the environmental requirements of Mil-E-5272C and senses accelerations from ±1 to ±50 g for each axis. It uses a potentiometer multiplying device and a short mass deflection to yield a high natural frequency. Each mass is suspended by a special flexure-principle — there are no friction-producing linkages on bearings.

The Model 620 is claimed to be highly reliable, with a maximum cross-axis acceleration error of 0.01 g/g. The operating temperature range is −65 to 165 deg F, with a power rating of ½ watt's continuous duty at 165 deg F. The dynamic error band is ±1 per cent, the tolerance on the band being applicable from 1 to 99 per cent of the rated range. **54**

Propulsion and Accessory Equipment

n Reader Service Card

Bellows-Operated Poppet Valve for Molten Metals



A new, bellows-actuated poppet valve that can function in systems handling molten lead, molten sodium or molten sodium alloys at temperatures up to 500 deg C has been developed by Hydrodyne Corp., 7350 Coldwater Canyon Ave., No. Hollywood, Calif., for applications in chemical, metallurgical, nuclear, and missile fields.

Featuring finely machined bellows and heliarc welded construction of Inconel-X, the valve can operate over a range of —430 to 1500 deg F at up to 450 psi. The pressure rating in other models extends to 10,000 psi. **56**

Crystal-Can Relay is Half Standard Size

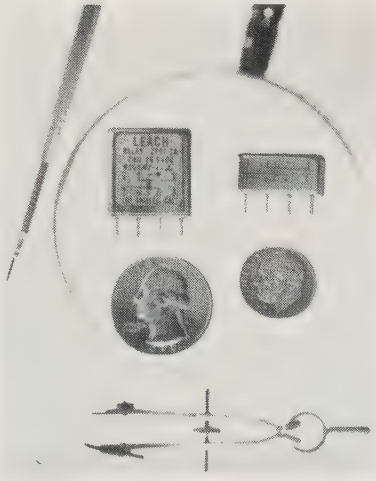
A new half-sized crystal-can relay, the M-250, offers space savings of 50 per cent over the smallest available subminiature crystal can, according to the Leach Corp., Relay Div., 5915 Avalon Blvd., Los Angeles 3, Calif.

The tiny relay weighs 0.35 oz and is 0.128 cu in. in volume. It is so small it can be used standing up without increasing the thickness of the package's "sandwiches."

Leach engineers say the M-250 frees the design engineer from the necessity of laying relays down horizontally, as with standard cans, and eliminates hold-down tabs.

Entire printed-circuit packages can therefore be greatly reduced, since three vertical self-anchoring relays can now be used in the space formerly occupied by a single conventional crystal can.

The new relay is also claimed to be less sensitive to vibration



forces, and to be more reliable in that it uses a single-coil electromechanical circuit instead of the two coils in the standard subminiature can. **57**

DEPTH TRANSDUCER for ASW use

Model 734 sea water depth transducer has been announced by **Bourns, Inc., Dept. S/A, 6135 Magnolia Ave., Riverside, Calif.** The unit provides the same high accuracy output in turbulent water as during static conditions, says the company.

The outstanding accuracy of this new instrument is reflected in the static error band of ±0.5 per cent. Specifications on this model include: range—350 to 1000 psia; resistance—5K to 10K ohms; resolution—0.15 per cent; vibration—35 g at 2000 cps; weight—approx 16 oz.

No. 472 on Reader Service Card

RPI space age support products . . .

NEW

UNIVERSAL EJECTOR RACK

. . . handles any

SUSPENDABLE STORE

Cut costs and installation problems with this unique Rocket Power "all purpose" rack, the MAU12/A, first to handle so wide a variety of stores—special weapons, missiles, conventional bombs, camera pods, and auxiliary tanks.

Developed for the U. S. Air Force Special Weapons Center for use on several Fighter-bombers, Bombers and V/STOL aircraft, this RPI rack features *adjustable* ejection force and all required safety devices. It is easily attached to the aircraft and provides both 14" and 30" hook spacing.

FOR TECHNICAL DATA on the RPI Universal Ejector Rack write for Bulletin #1500.

ROCKET POWER INC.

FALCON FIELD/MESA, ARIZONA

OFFICES: Pasadena/Dayton/Washington, D.C

No. 109 on Reader Service Card

In engineering and manufacturing AMF has ingenuity you can us

He has a hand in planning for the men in the moon

He's one of a staff of AMF engineers who are solving space environment problems on a here-and-now basis.

He has plans for an orbital launch facility (picture, top left) to help them get there in the first place. Inside, in a shirt-sleeve environment (top, right), a space vehicle can be prepared for launch to the moon itself. On the moon (center), connected structures above and below the surface are required for the Advanced Habitation Engineering needed to support a permanent lunar base. Lunar traverser (bottom) is used to move men and materials and assist in construction of a permanent base.

Already, AMF has designs and concepts which make those pictured obsolete. As new knowledge becomes available, AMF quickly incorporates it into simpler, more reliable, more easily fabricated mechanisms.

AMF has completed and is now carrying on studies and feasibility investigations covering a wide range of space environment problems in conjunction with space vehicle manufacturers and for several government departments. Space environment, itself, is just one of a virtually complete spectrum of AMF defense capabilities.

For more information, write American Machine & Foundry Company, Government Products Group, AMF Building, 261 Madison Avenue, New York 16, N. Y.

AMF

• AMERICAN MACHINE & FOUNDRY COMPANY

No. 110 on Reader Service Card

TIME DELAY RELAY is voltage-compensated

A new type of subminiature time delay relay offering instant re-cycling with 100 per cent recovery of the pre-set delay time has been developed by **Branson Corp., Dept. S/A, 41 So. Jefferson Rd., Whippany, N.J.**

A unique circuit design provides voltage compensation for both ac and dc in a range from 6 to 115 volts. The delay time is factory pre-set from 15 to 300 sec. The unit is said to provide a high degree of accuracy.

No. 270 on Reader Service Card

SERVO ACCELEROMETERS for precision guidance

A line of triaxial, biaxial, and unidirectional servo accelerometers has been announced by **Gulton Industries, Inc., Dept. S/A, 212 Durham Ave., Metuchen, N.J.** Suitable as an aid for inertial guidance, they are packaged complete with electronics requiring only one mounting surface. Internal axes are oriented within one minute of arc.

Designed for ±15 or 28 volt dc operation, they provide precise measurements for guidance systems requiring secondary acceleration sensing capability in two or more planes simultaneously.

No. 271 on Reader Service Card

FLOW CONTROL VALVE eliminates by-pass

This co-axial metering flow control valve is classified as a dual purpose valve by **Kell-Strom Tool Co., Inc., Dept. S/A, Wethersfield, Conn.**

The unit eliminates the use of a by-pass valve in conjunction with a discharge flow control valve and extra plumbing to provide fine metering of fluids under high or low pressure in one body. Finger tip controls are provided for fine or coarse adjustments.

No. 272 on Reader Service Card

DC MOTOR for missile hydraulics

This 27-volt DC motor was designed to power a missile hydraulic pump by **Hoover Electric Co., Dept. S/A, 2100 S. Stoner Ave., Los Angeles 25, Calif.** It is also adaptable for use in aircraft, missiles, and ordnance, on actuators, blowers, pumps, etc.

Typical specifications are: 2.5 hp continuous duty at 3050 rpm; 4.0 hp intermittent duty at 2700 rpm; 70 per cent efficiency; 14.9 lb weight; and 9.75 x 5.00 x 6.47 in. dimensions.

No. 273 on Reader Service Card

ANGLE POSITIONER accurate to 3 seconds

Production of the CO56402004 precise angle positioner has been announced by **Kearfott Div., General Precision, Inc., 1150 McBride Ave., Little Falls, N.J.** In typical applications, it is used in conjunction with a resistance bridge and null device to measure the accuracy of synchro components.

Features of the unit include accuracy to ±3 sec, specially mounted dial indicator, integral synchro bridges, aluminum housing, and simplified action for inserting and removing test components. Specs include repeatabil- readout range of ±2½ deg, and 55 lb weight.

No. 274 on Reader Service Card

PRESSURE GAGE is accurate to 1 per cent

A miniature pressure transducer, Model **451218**, available in a variety of pressure ranges, pressure modes, electrical connections, and mounting arrangements is offered by **Giannini Controls Corp., Dept. S/A, 1600 So. Mountain Ave., Duarte, Calif.** The unit is suitable for in-flight surface pressure measurement, missile and space vehicle telemetering, aircraft altitude sensing, and aircraft pitch and yaw control.

Hermetically sealed, the Model 451218 meets MIL-E-5272C and MIL-E-5400. Ranges available are from 0 to 10 to 0 to 150 psi. The operating temperature range is −54 to 85 deg C. Acceleration capability is 20 g operating, 40 g max. Maximum weight is 1 oz, and the volume is 1 cu. in.

No. 275 on Reader Service Card

VANE TYPE SENSOR measures angle of attack

A vane type sensor which measures angle of attack in the Mach 5 range has been developed by **U. S. Science Corp., Dept. S/A, 5221 W. 102 St., Los Angeles 45, Calif.** Variations as low as 1/10 deg in a vehicle's local angle of attack are sensed by the vane through change in direction of the airflow over the axis of the vane.

Model 16608 operates at altitudes from 0 to 150,000 ft, at Mach 5, maintaining an accuracy of 0.1 deg. It weighs 4 lb, has an effective angle of 50 deg, and a time constant of 50 ms. Transmitter sensing elements operate up to 2250 deg F, with self-regulating heaters in the sensor vane protecting the unit against icing effects.

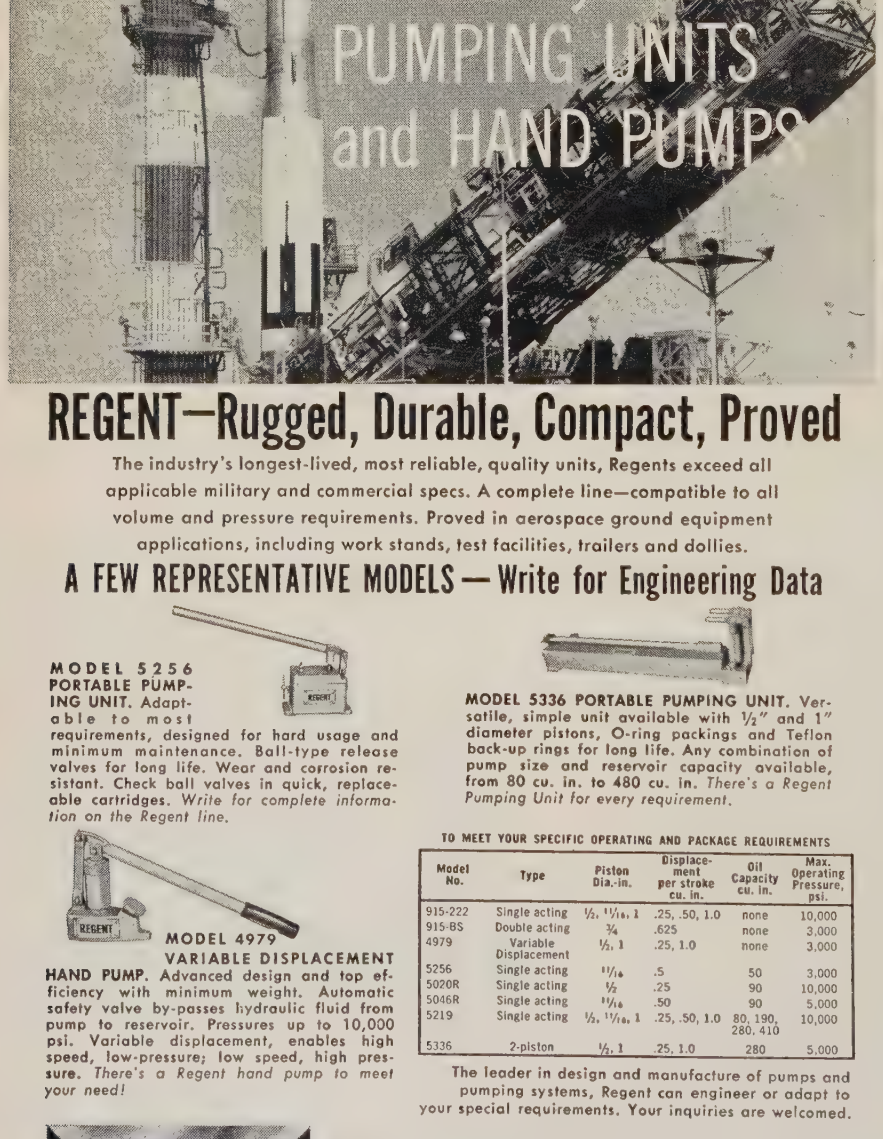
No. 276 on Reader Service Card

SOLAR CELLS *with increased efficiency*

Silicon solar cells which provide electrical power for space vehicles are available with conversion efficiencies as high as 13 per cent. The achievement is a result of a new collector strip process developed by **International Rectifier Corp., Dept. S/A, El Segundo, Calif.** Cells have secondary collector strips protruding from the main or primary strip, thus affording better collection of the current from the active cell area. The collectors form a grid network over the active area of the cell.

The higher operating voltage and lower impedance resulting from the new process affords an increase in cell output power over non-gridded cells of up to 20 per cent, under given light and load conditions.

No. 277 on Reader Service Card



REGENT—Rugged, Durable, Compact, Proved

The industry's longest-lived, most reliable, quality units, Regents exceed all applicable military and commercial specs. A complete line—compatible to all volume and pressure requirements. Proved in aerospace ground equipment applications, including work stands, test facilities, trailers and dollies.

A FEW REPRESENTATIVE MODELS — Write for Engineering Data

MODEL 5256 PORTABLE PUMPING UNIT. Adaptable to most requirements, designed for hard usage and minimum maintenance. Ball-type release valves for long life. Wear and corrosion resistant. Check ball valves in quick, replaceable cartridges. *Write for complete information on the Regent line.*

MODEL 5336 PORTABLE PUMPING UNIT. Versatile, simple unit available with ½" and 1" diameter pistons, O-ring packings and Teflon back-up rings for long life. Any combination of pump size and reservoir capacity available, from 80 cu. in. to 480 cu. in. *There's a Regent Pumping Unit for every requirement.*

MODEL 4979 VARIABLE DISPLACEMENT HAND PUMP. Advanced design and top efficiency with minimum weight. Automatic safety valve by-passes hydraulic fluid from pump to reservoir. Pressures up to 10,000 psi. Variable displacement, enables high speed, low-pressure; low speed, high pressure. *There's a Regent hand pump to meet your need!*

TO MEET YOUR SPECIFIC OPERATING AND PACKAGE REQUIREMENTS

Model No.	Type	Piston Dia.-in.	Displacement per stroke cu. in.	Oil Capacity cu. in.	Max. Operating Pressure, psi.
915-222	Single acting	½, 1 1/16, 1	.25, .50, 1.0	none	10,000
915-BS	Double acting	¾	.625	none	3,000
4979	Variable Displacement	½, 1	.25, 1.0	none	3,000
5256	Single acting	1 1/16	.5	50	3,000
5020R	Single acting	½	.25	90	10,000
5046R	Single acting	1 1/16	.50	90	5,000
5219	Single acting	½, 1 1/16, 1	.25, .50, 1.0	80, 190, 280, 410	10,000
5336	2-piston	½, 1	.25, 1.0	280	5,000

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ACCELEROMETER *for longitudinal sensing*

The Model 2062 accelerometer which instantaneously displays visual or photographic warning information is designed to sense acceleration in the longitudinal direction in the range of −10 g to 22 g. Scale error is said to be ±0.5 g.

Developed by **Burton Mfg. Co., Dept. S/A, 2520 Colorado Ave., Santa Monica, Calif.,** the unit makes use of an indicating pointer and two memory pointers which store maximum excursions of the indication pointer. The accelerometer requires no external connection. Measuring 2.38 x 2.38 x 4.75 in. long, the unit meets the environmental stresses encountered during space vehicle launching and reentry.

No. 278 on Reader Service Card

ELECTRICAL COUPLING *has low extraction force*

A new electrical coupling is a quick connect/disconnect device with the added feature of complete environmental protection. Originally developed for missile separation, it requires only 0.8 lb force to extract the pin forming the connections.

According to **Kellett Aircraft Corp., Dept. S/A, Willow Grove, Pa.,** connection can be made with an angular misalignment of 5 deg between the surfaces of the coupling. On Model P/N 200-73004, the contacts are rated at 45 amps and have a solder pot for wires up to and including 12 AWG wire. The contacts are capable of meeting the applicable electrical and vibration requirements of specification MIL-C-5015.

No. 279 on Reader Service Card

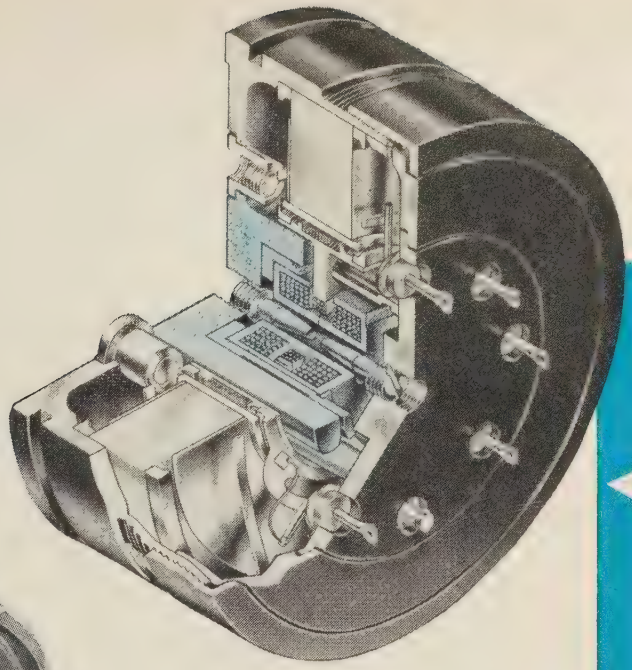
TRANSDUCER *for rugged service*

A pressure transducer designed specifically for exceptional extra rugged service and accuracy has been announced by **Consolidated Electrodynamics Corp., Dept. S/A, 36 Sierra Madre Villa, Pasadena, Calif.** Featuring an over-pressure capability of 10 times rated range, it is reported to be the most indestructible transducer available.

This type 4-350 instrument features a sensitivity of 50 mv, low residual unbalance, and a combined figure of ±0.35 percent for linearity and hysteresis. Pressure ranges are from 0-100 to 0-5000 psi, gage or absolute. Shocks up to 1000 g will not damage the instrument, says the company.

No. 280 on Reader Service Card

No. 111 on Reader Service Card



Originally conceived for Norden's miniature, all-attitude 20-pound platform . . . and flight-tested for 15 months. Now in production and available on short delivery.

NORDEN

INERTIAL COMPONENTS

NORDEN MINIATURE SINGLE AXIS ACCELEROMETER

ACHIEVES HIGH ACCURACY IN A COMPACT PACKAGE

Norden's force-balance linear accelerometer, with discriminating single axis detection system, provides high order precision in a miniature package . . . fulfills exacting requirements for accuracy in such applications as: inertial systems, missile instrumentation, and antenna level sensing equipment. Proved in the rugged 15-month flight test of Norden's 20-pound inertial platform, this advanced accelerometer design offers:

- **THRESHOLD**—single axis detects changes as small as 1 second of arc.
- **RELIABILITY**—translatory motion of proof mass reduces cross-coupling and susceptibility to rectification.
- **VERSATILITY**—range and performance characteristics can be varied by changing amplifier components.
- **FLEXIBILITY**—sensor and amplifier can be installed in separate locations.

TYPICAL SPECIFICATIONS

Weight	8.0 oz.
Size	2 x 0.875 in.
Threshold sensitivity	5×10^{-6} g.
Operating range	±10 g.
Range	2—20KC
Output	Direct Current
Linearity	
10^{-4} to 0.2 g	10^{-4} g (max. deviation)
0.2 to 1.0 g	0.015% of actual value
1.0 to 10.0 g	0.03% of actual value

For illustrated literature, containing complete specifications and performance data, on this and other models, call TEmple 8-4471, TWX NWLK 21, or write to . . .

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No. 112 on Reader Service Card

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Thrust Vectoring → Nozzle Gimballing and Secondary Injection

Thrust Ranges → 0.01 lbs. to 600 lbs.

Temperature Ranges (Fluid) → −65° to +6000°F.

Response Ranges → 4 mil-seconds to 90 mil-seconds

Total Impulse → 10 lb./sec. to 100,000 lb./sec.

Pressure Ranges → 2 psi to 7500 psi

Duration and Environmental Temperature (Atmosphere-Space) → −80° to +1500°F.; 15 hours

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VISIT THE KIDDE BOOTH #264, A.R.S. FLIGHT REPORT, OCT. 9-15, NEW YORK COLISEUM.

AXIAL SEAL is extremely small

Only slightly larger than the head of a pin, a hermetically sealed axial seal has been developed by **Mechtronics Corp., Dept. S/A, 11431 Joanne Place, Culver City, Calif.**

The seal provides a jewel-end bearing at each end of a gimbal within a fluid-filled gyro. In use, it permits an axial adjustment of the gimbal for its proper orientation with respect to the gyro case. The unit is 0.140 in. od by 0.070 in. long and extends 0.025 in.

No. 281 on Reader Service Card

BUTTERFLY VALVE features low leakage

An airborne, 3-in. butterfly valve, designed to handle liquid hydrogen and LOX on the Saturn, has leakage values of less than 10 cc/min helium at cryogenic temperatures, says **B. H. Hadley, Inc., Dept. S/A, 1427 S. Garey Ave., Pomona, Calif.**

The valve is equipped with a double acting pneumatic actuator and its associated solenoid operated 4-way valving, limit switches, and overriding spring closure in the event of loss of actuating supply pressure.

No. 282 on Reader Service Card

SEALED SWITCHES pass spec MIL-E-5272

Originally developed for specific aircraft application, a new group of hermetically-sealed switch has been introduced by **Control Switch Div., Controls Co. of America, Dept. S/A, 1420 Delmar Drive, Folcroft, Pa.**

This group of hermetics includes both single-pole, double-pole, and four-pole units. They feature an ambient temperature range of −65 to +250 deg F and will pass immersion test MIL-E-5272.

No. 283 on Reader Service Card

PRESSURE TRANSDUCER offers high output

An all-stainless steel pressure transducer has been developed for precise measurements in areas of limited space by **United Aero Products Corp., Dept. S/A, Columbus Rd., Burlington, N.J.** Designated type 78-C, it uses a welded Ni Span C pressure element linked inductively to an ultra-sensitive transformer.

The unit is reported to provide high continuous output with exceptional repeatability and low acceleration response. It is available in ranges from 0-5 to 0-350 psi. The unit measures 1¼ in. od.

No. 284 on Reader Service Card

No. 113 on Reader Service Card

Insulation news from Johns-Manville

Now Min-K® is flexible!

THE INSULATION WITH A LOWER CONDUCTIVITY THAN STILL AIR IS NOW AVAILABLE IN BLANKET AND TAPE FORMS FOR UNLIMITED NEW APPLICATIONS

Min-K, the unique insulating material developed and produced by Johns-Manville, now has an added quality . . . flexibility! Min-K is a new concept in missile insulation. The higher it flies, the better it insulates. Min-K's thermal conductivity drops as atmospheric pressure decreases. Its superior performance has been proved in hundreds of operational U. S. missiles.

New Flexible Min-K offers many special advantages. For example, it is the ideal way to lower prototype costs. You can test performance without the expense of special tooling. The flexible blankets lend themselves to bonding, lamination with reinforced plastics, service coatings and as a component of insulation systems. Further, Min-K can be tailor-made to wrap around a cylinder, cone or other geometric shape. And, it is also available in $1\frac{1}{2}$" and 2" tapes for spiral winding on a duct or pipe.

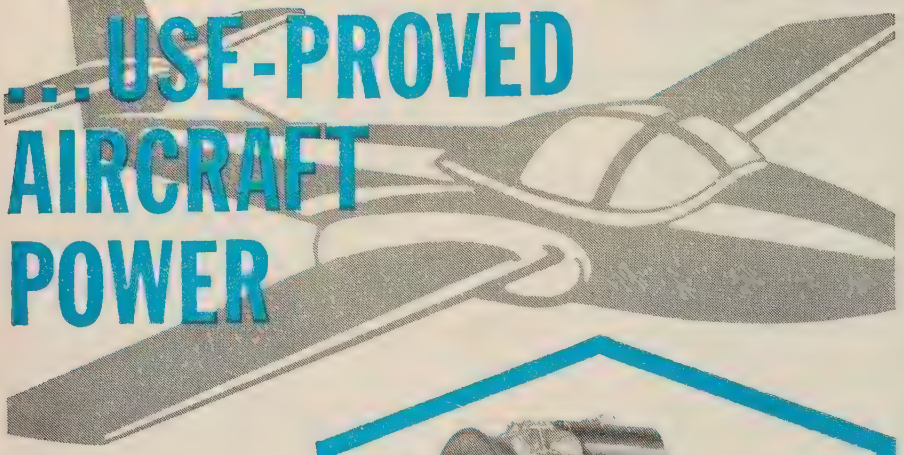
Because of the added quality of flexibility, Min-K's unique insulating characteristics now can be used in virtually unlimited new applications. For full details on Flexible Min-K, Min-K and other J-M aviation insulations, write Johns-Manville, Box 14, New York 16, New York. In Canada: Port Credit, Ontario. Cable address: Johnmanvil.

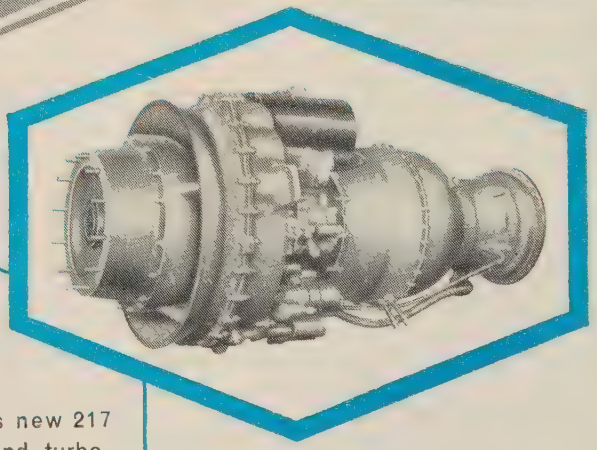
JOHNS-MANVILLE

JM PRODUCTS

No. 114 on Reader Service Card

The CONTINENTAL 217 ...USE-PROVED AIRCRAFT POWER





Behind Continental's new 217 series of turboshaft and turboprop engines for business and utility aircraft is a truly impressive record of military service. For the 217 has evolved directly from the highly successful J69, power plant of the Cessna T-37 Trainer and the Q-2C Target Missile, which has withstood 40,000 test stand hours, and more than a million hours in flight.

Model 217-5A has 6000-rpm output shaft, Model 217-6A has 2100-rpm flanged propeller shaft drive. Both versions combine high performance and operating economy with long life, low weight, LOW INSTALLED COST.

PERFORMANCE

500 SHP, with high economy (0.67 SFC).

RELIABILITY

Simple, rugged design . . . Foreign-object-tolerant all-steel rotating system . . . Anti-icing inlet . . . Fail-safe dual element fuel pump . . . Trouble-free fuel distribution system . . . Emergency fuel circuit with manual controls.

INSTALLATION ADVANTAGES

Compactness (19-in. overall diam., 42-in. overall length) . . . Straight-out rear exhaust—no obstructions or turns . . . Front power output on engine center line . . . Front reduction gear surrounded by cool air . . . High accessibility—all accessories mounted around waist . . . Optional mounting: single plane, two-plane, or cantilever . . . Low weight (245 lbs.).

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No. 115 on Reader Service Card

INSTRUMENT SWITCH has 20 decks

A new instrument switch utilizes floating stainless steel shafts and a pressure equalizing brushes to enable use of up to 20 decks. These units, according to **Langevin, Div., Sonotec Inc., Dept. S/A, 503 S. Grand Ave., Santa Ana, Calif.**, are made to conform to military specifications and are designed especially for dry circuits.

A captive rotor design makes all decks integrated, self-aligning assemblies. Contacts, collector rings and one-piece brushes are all fine silver which eliminates the effects of oxides and sulphides, thus producing no thermal voltages.

No. 285 on Reader Service Card

CRYOGENIC SEAL is reusable

This cryogenic metal seal, which has been used in Thor, Atlas, and Jupiter rockets, is now available as an "off-the-shelf" item. Tradenamed "Naflex" by **Rocketdyne Div., North American Aviation, Inc., Dept. S/A, 6633 Canoga Ave., Canoga Park, Calif.**, the seal is said to be repeatedly re-usable.

Providing leakproof sealing through high and low pressure extremes, it requires significantly lower bolt and flange loads than necessary for gaskets and for most other types of seals, says Rocketdyne. The seal is available in sizes from 1 to 20 in.

No. 286 on Reader Service Card

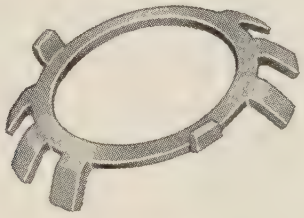
SILVER-ZINC BATTERY provides auxiliary power

Power for an ICBM decoy system is available with an automatically activated primary silver-zinc battery, designated Model P134A, designed by **Power Sources Div., Telecomputing Corp., Dept. S/A, 3850 Olive St., Denver, Colo.** The battery has two sections. One provides 29 volts at 1 amp for 25 min, the other 28 volts at 8 amp for 3 min.

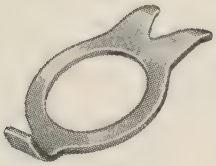
The battery utilizes a piston-tank mechanism which activates the battery in less than one sec. Model P134A measures 2¼ x 4 x 6 in. and weighs 3 lb. The unit exceeds the environmental requirements of MIL-E-5272. Case configurations may be specified to meet critical volume requirements.

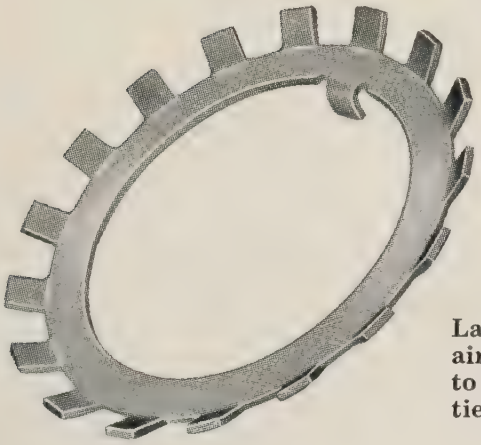
No. 287 on Reader Service Card

THE MARKETPLACE



FOR AIRCRAFT-QUALITY STAMPED METAL PARTS





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Would you let this salesman talk to your plant people?

He represents Snap-on Tools Corporation — home office, Kenosha, Wisconsin. He sells hand tools for production and maintenance — items like impact socket wrenches and shanks for high-speed power assembly, mechanics' wrenches and tools for hand assembly. Far more important, he brings cost-saving *ideas* on tool use. For example:

He will check your production line — point out any areas where tool changes could save time, cut costs.

On problem jobs, such as close-quarter work, hard-to-reach fittings, he can recommend special tools, refer idea sketches to SNAP-ON® design engineers. Often, however, among its over 4,000 items, SNAP-ON already makes a tool that fits your needs exactly.

Before a maintenance shutdown, he will go over equipment to be serviced with your maintenance man, then check your tools and make recommendations. Properly tooled-up at the start, you eliminate costly repair delays.

If your customers require tools in the operation of your product, the SNAP-ON representative can make up special tool kits to go out with each unit you sell.

Most important, the SNAP-ON sales engineer is *qualified* by training and experience to do all these things — and more. Tools are his only business. He is a specialist in daily contact with a wide variety of tool problems.

So, would you let *this* salesman talk to *your* plant people? In companies that have, the SNAP-ON tool specialist is a welcome member of the plant team. Contact your nearest SNAP-ON branch or write us.

FOR ALL INDUSTRY

SNAP-ON TOOLS

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ACCELEROMETER *is extremely sensitive*

The high output of this model 2219, 250 pk-mv/pk-g accelerometer offers new possibilities for measuring low vibration levels, says **Endevco Corp., Dept. S/A, 161 E. California Blvd., Pasadena, Calif.** Combining the unit with their model 2607M4 amplifier and model 2624 power supply provides a signal-to-noise ratio of 10 db for 0.0002 peak g.

Resonance frequency is reported as 13 kc nominal; temperature response with 100 pf external capacity is ±8 per cent nominal deviation for 32 to 230 deg F; weight is 2.75 oz; and size is 0.917 x 0.812 x 15/16 in.

No. 288 on Reader Service Card

SEAL RING *has X-shaped section*

A seal ring which combines the characteristics of rubber O-rings with the physical properties of FEP-fluorocarbon resin has been developed by **Allegheny Plastics, Inc., Dept. S/A, Coraopolis, Pa.** Because of the X-shaped cross-section, these cup-type seal rings provide more resilience, to eliminate the close tolerances required with O-rings.

Called X-Seals, the rings are said to improve performance in many applications on oscillating, reciprocating, and rotating shafts, as well as in static applications. Like other cup-type seals, sealing efficiency increases with pressure. The rings offer an extended range of service 300 to 500 deg F, need no lubrication and have low break-away friction.

No. 289 on Reader Service Card

SERVO MOTOR *for high-gain systems*

This inertially damped servo motor has been developed by **Wright Machinery Co., Dept. S/A, Durham, N.C.,** for use in high gain servo systems of advanced missiles. A 6-pole, 400-cycle size 15 motor, it produces a much high torque-to-inertia ratio than normally found in this size servo. It also features large flywheel damping and very broad frequency response.

Pertinent data include: theoretical acceleration at stall—22,700 rad/-sec^2; minimum power output—1.151 watt; input power at stall—6.1 watt; motor dampening—130 dyne-cm sec; weight—18 oz; no load speed—6200 rpm.

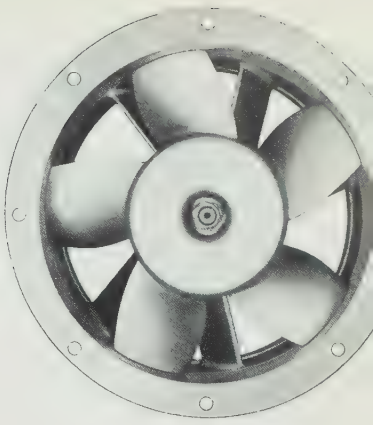
No. 290 on Reader Service Card

No. 117 on Reader Service Card

No. 168 on Reader Service Card

MOVING
AIR
IS
CHILD'S
PLAY

CONTROLLING
IT
TAKES
AN
EXPERT



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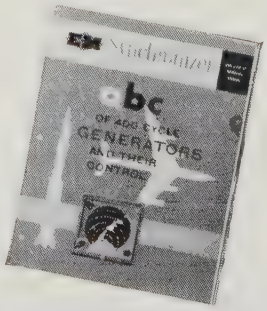
Whatever your requirements in 400 cycle ground power equipment, E-M's large staff of specialists, with unmatched 400 cycle generator experience, can help. Missiles and jet aircraft that now have the advantages of E-M's imaginative engineering of 400 cycle ground power generators include Titan, Nike-Hercules, Snark, Matador, Hound Dog, B-47, B-58, and B-52.

Designing and building 400 cycle generators to meet the exacting requirements of missile and jet applications requires a big investment in experienced, technical manpower and plant facilities. Ask your nearby E-M Field Engineer to show you his copy of "Ground Power for Space". It's an informative picture story of E-M's investment in your 400 cycle ground power needs.

FREE 28-PAGE ILLUSTRATED BOOKLET offers many answers to your 400 cycle ground power questions. Write the factory for a free copy of "ABC of 400 Cycle Generators and Their Control". It's packed with useful information about performance characteristics and mechanical construction of 400 cycle ground power generators.



E-M

2600-TPA-2200-A

ELECTRIC MACHINERY MFG. COMPANY
Minneapolis 13, Minnesota

STEPPING SWITCH has 104 positions

A fast-acting, solenoid operated, rotary stepping switch which has 104 contacts is available from **Astral Electronics, Inc., Dept. S/A, 14620 Arminta St., Van Nuys, Calif.**

The switch actuating mechanism is a vibration free rotary solenoid, operated by an external pulse. Standard input voltage is 24 volts dc, with other coils available to meet special requirements. Contact carrying capacity is 2 amps, working voltage between adjacent contacts is 3000 volts dc. with a maximum resistance drop through contacts of 0.05 ohms.

No. 324 on Reader Service Card

FILTER CHAMBERS for corrosive chemicals

Miniature filter chambers for filtering small volumes of corrosive chemicals as well as solvents are offered by **Sethco Mfg. Corp., Dept. S/A, 2284 Babylon Turnpike, Merrick, N. Y.**

Available in lucite, epoxy, PVC, and teflon, these filter chambers measure 5 in. high x 2 in. in diameter, weigh approximately 8 oz, and have a filtering capacity of 5 to 7.5 gal/hr.

No. 325 on Reader Service Card

RELIEF VALVES for hot gases

Two new valves provide pressure control for safety protection in hot gas systems of liquid or solid propellants. Designed by **Circle Seal Development Corp., Dept. S/A, 1537 Embassy St., Anaheim, Calif.**, the valves use a gas reference pressure for relief pressure control. This design feature permits ready adjustment of relief setting from a remote source.

Relief pressure capabilities range from 10 to 1500 psi with temperature to 2200 deg F. The valves are suitable for air, nitrogen, combustion or decomposition gases.

No. 326 on Reader Service Card

STATIC SPRING SEAL is Inconel-X

A contoured static spring seal, which is essentially a manifold seal, is now available from **Hydrodyne Corp., Dept. S/A, 7350 Coldwater Canyon Ave., N. Hollywood, Calif.** Manufactured from silver-plated Inconel-X, it can handle temperatures from −320 to +1500 deg F.

Spring action is achieved from a bellows configuration created by finely machine grooves in the heat-treated metal ring. The seal immediately resumes its original free length after release from compression.

No. 327 on Reader Service Card

No. 118 on Reader Service Card

RYAN—
ONLY VOLUME PRODUCER
OF DOPPLER NAVIGATORS FOR HELICOPTERS

Most experienced in the field of Doppler navigation, Ryan Electronics, over the last fourteen years has pioneered the major advances in the application of C-W Doppler to airborne navigation.

In production and in use for years, RYANAV sets for helicopters, V/STOL, and fixed wing aircraft have been proven under the most difficult operating conditions throughout the world.

Small, lightweight, reliable, with the highest performance capabilities, RYANAV sets are the most advanced and most versatile yet devised. Completely self-contained, RYANAV Doppler measures all-direction velocity over all terrain under all-weather conditions. It is compatible with navigational aids, autopilot, and automatic control devices requiring accurate speed sensing.

RYANAV sets are available now. Ground Speeds: minus 50 to 2,000 knots. Vertical Velocity to 60,000 feet per minute. And Altitudes to 70,000 feet.

The U. S. Government, and other nations of the Free World rely on Ryan as the producer of Doppler navigators for helicopters. Ryan Electronics—Ryan Aeronautical Company, San Diego, California.

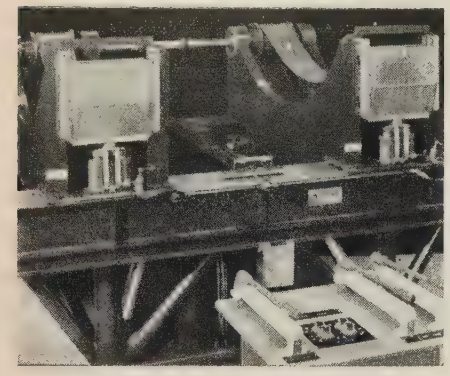
RYANAV Doppler Navigators now in full production for helicopters (over 500 already in use): AN/APN-97A Helicopter Ground Velocity Indicator; AN/APN-130 Helicopter Hovering and Ground Velocity Indicator.

Ryan Electronics offers challenging opportunities to engineers

RYAN
ELECTRONICS

No. 119 on Reader Service Card

INSTRUMENTATION FOR AEROSPACE



This Center of Gravity Locator for 20,000 pound-class space vehicles is typical of Dynametric's capabilities in aerospace instrumentation.

- Weight, Center of Gravity, Inertia
- Thrust Stands
- Force Calibrators
- Pressure Instruments and Systems
- Aerodynamic Models and Balances

Your inquiries are welcome. Write for further information to

DYNAMETRICS CORPORATION
Northwest Industrial Park
Burlington, Massachusetts
No. 120 on Reader Service Card

SOLID STATE SWITCH reported noiseless

A solid state switch that produces no transients into the power line when switching the load has been announced by **L J Products, Dept. S/A, 7464 Girard Ave., La Jolla, Calif.** Because no current or voltage is required to actuate the input contacts, only a resistive opening or closing of the input contact is required.

There are no moving parts, and thus response time is extremely fast. The unit measures 0.75 x 1.625 x 1.093 in. and weighs only 2.5 oz. Models are available for 5-amp, 10-amp, and 20-amp load circuits at 115 volts AC.

No. 291 on Reader Service Card

STATIC SEAL operates to 10,000 psi

This two-stage static seal in which a high yield-strength stainless steel V-ring is preceded by a Teflon seal is now available from **Pall Corp., Dept. S/A, 30 Sea Cliff Ave., Glen Cove, N.Y.** The seal is designed to operate from −65 to +600 deg F under pressures up to 10,000 psi.

The outer ring maintains the seal under extreme temperatures and pressures—the Teflon primary seal provides a soft seat for leaktight sealing. It is reported highly resistant to corrosion and compatible with nearly all fluids.

No. 292 on Reader Service Card

ACCELEROMETER is used as level sensor

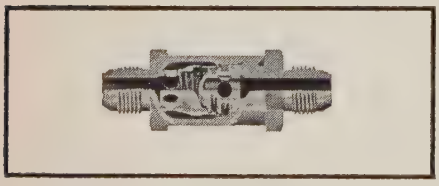
The production of the B2400-01A two-axis accelerometer, an accurate and stable instrument designed primarily as a level sensor, has been announced by **Kearfott Div., General Precision, Inc., Dept. S/A, 1150 McBride Ave., Little Falls, N.J.** The sensing element of this device is an inverted pendulum captured by a force balance servo loop.

Long term stability is 2 x 10^{-5} per year, linearity is 3 x 10^{-6} for ±2 deg of arc tilt, threshold is 5 x 10^{-7} g, and mounting surface flatness is within 1 second of arc. Maximum range is ±0.035 g, but it can be modified to provide a range of measurement up to ±1 g.

No. 293 on Reader Service Card

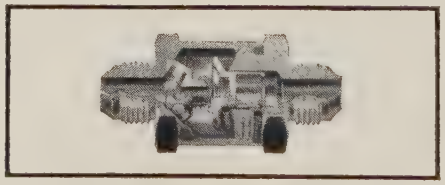
CIRCLE SEAL CHECK VALVES
...no leakage, even with Helium

Proven reliability of the basic Circle Seal design, supplemented by precision production techniques, have made Circle Seal valves renowned for operational dependability in the most critical aircraft, missile and ground support applications.



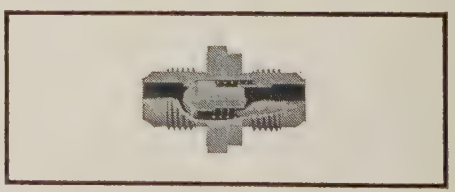
200 SERIES CHECK VALVE

- Absolute zero leakage
- 0-3000 psi.
- Low cracking pressure
- Mounting versatility for any application
- Ideal in applications from vacuum to low or high pressure pneumatic or hydraulic systems encompassing the entire range of exotic fuels and oxidizers



800 SERIES CHECK VALVE LOW PRESSURE

- Perfect sealing from 0-600 psi.
- Low cracking pressure
- Minimum pressure drop
- Unaffected by O-ring swell
- Perfect for applications requiring a combination of low pressure drop and zero leakage



2600 SERIES MINIATURE CHECK VALVE

- Superior performance from 0-3000 psi.
- Leakproof sealing assured by resilient seals
- Minimum size and weight
- Suitable for mounting in any position
- Maintenance-free reliability

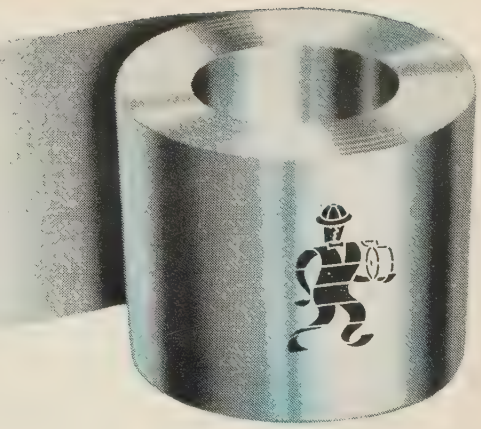
CIRCLE SEAL® precision valves

JAMES, POND & CLARK, INC.
2181 East Foothill Boulevard • Pasadena, California

No. 121 on Reader Service Card

Reliable Rodney asks:

NEED *Stainless Steel* PRECISION GAUGE THIN STRIP OR FOIL?



SPECIALISTS IN CLOSE-TOLERANCE THINNESS

Rodney concentrates its entire efforts, research and production, toward furnishing super thin, extra wide, cold rolled precision gauge strip in all tempers and finishes. With the entire capacity of the plant and personnel devoted exclusively to this specific area, Rodney has acquired a wealth of "know-how", manufacturing experience, quality control, and application knowledge . . . ready for your use!

STAINLESS STEEL STRIP — All Alloys

Widths — ⅛" to 24" Gauges — .012" to .0003"
All Tempers and Finishes.

Rodney furnishes Stainless Steel Strip in all alloys, but specializes in Types 301, 302, 304, 305, 316, 321, 347, 17-7PH, PH15-7MO, 410 and 430, the most commonly used. Rodney's unique ability to produce strip in gauges as thin as .0003" and as wide as 24" makes, in effect, a new kind of material available to design engineers and fabricators. Rodney furnishes strip in all finishes to meet your requirements.

In many applications, Rodney's bright annealed stainless steel makes polishing unnecessary. For example, 300 Series Stainless Steel is available in dead soft temper with a mirror finish on both sides.

For high tensile strength applications material can be furnished approaching 300,000 PSI. Intermediate tempers are also available. Thickness tolerances, when required, can be held to within ±3% of gauge even across the widest strip.

SPECIAL ALLOYS

Exotic metals, high temperature and other special alloys for space age applications are regularly rolled to exacting specifications by Rodney. Rodney's laboratory is fully equipped with the latest instruments for mechanical and chemical testing, and Rodney's experienced research and development personnel are always available for consultation on your special problems.

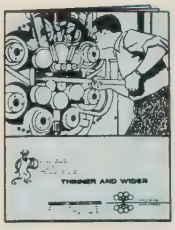
ALUMINUM ALLOYS AND CARBON STEEL STRIP

Precision processed to exacting specifications on request.

SPECIALTY CUSTOM ROLLING

Rodney will work with you on special super thin rolling of all metals, pure or alloy, within the general range of .0003" to .005" thickness and in widths up to 12½".

- PRECISION ROLLING
- RANGE OF MATERIALS
- QUALITY CONTROL
- HIGH FINISH
- CONTROLLED HEAT TREATING
- ON TIME DELIVERIES
- ACCURATE SLITTING
- COMPLETE RESEARCH AND ENGINEERING FACILITIES AND SERVICES



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Executive Offices: 261 Fifth Avenue, New York 16, N. Y.
West Coast Office & Warehouse: 5462 East Jillson Street, Los Angeles 22, Calif.

No. 122 on Reader Service Card

LARGEST NUMERICAL DISPLAY AVAILABLE

WITH KEARFOTT'S DME COUNTER-INDICATOR

With numerals 5/16" in height, this Kearfott unit has a larger, more easily read numerical display than any other DME indicator. This size factor contributes greatly to speed and accuracy in reading, and it provides an added margin of insurance against navigational error.

The Kearfott Single DME Counter-Indicator shows distance (in units, tens, and hundreds of nautical miles) from the aircraft to a navigational beacon. A mask with rectangular apertures allows only the significant calibrations to be seen; and when no signal is impressed, a red flag extends across the apertures to prevent reading. The unit is hermetically sealed and is filled with dry inert gas for trouble-free dependability and maximum service life.

In addition to the Single DME Counter-Indicator (T8510-11N) shown above, a Dual DME Counter-Indicator (T8511-11N) is available which indicates aircraft distance from each of two navigational beacons. The units meet environmental requirements and other applicable portions of RTCA Paper 100-54/DO-60.

SPECIFICATIONS

		T8510-11N (SINGLE)	T8511-11N (DUAL)
ACCURACY	Units Drum	±.05 mi	±.05 mi
	Tens Drum	±1/32 in.	±1/64 in.
	Hundreds Drum	±1/32 in.	±1/64 in.
SPEED	Either Direction	15 mi/sec	15 mi/sec
POWER	Rotor Voltage	26 ±2v ac, 400 ±10 cps	26 ±2v ac, 400 ±2 cps, 1 ph
	Flag Voltage	28 ±2v dc, 0.3 amp max	28 ±2v ac
WEIGHT		1¾ lbs	3 lbs

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

TRANSDUCER uses rigid mounting

A variable piezoelectric transducer, whose mount is said to eliminate more than 85 per cent of the noise produced by conventional transducers, has been developed by **Mirax Chemical Products Corp., Dept. S/A, St. Louis, Mo.** The transducer, called the "Variducer," measures shock velocity, blast pressure, and compression and expansion wave durations.

The unit is capable of withstanding temperatures to 300 deg C. The rated pressure range is 0 to 1000 psi. Rise time is 1 microsec, and voltage sensitivity is 30 millivolts per psi. The instrument measures 0.375 in. in diameter x 0.563 in. long.

No. 294 on Reader Service Card

INTEGRATING GYRO gives rate and position

Angular rate and position are obtainable with an integrating gyroscope designed specifically for aircraft and drone applications by **Whittaker Gyro Div., Telecomputing Corp., Dept. S/A, 16217 Lindberg St., Van Nuys, Calif.** The algebraic sum of the individual signals is provided on a single pickoff. The gyroscope is a single-degree-of-freedom instrument with no mechanical restraint between the gimbal and frame.

An electrical torque generator together with an integrating network provides the necessary restraint for size, says **Microporous Filter, Dept. S/A, 1537 Embassy St., Anaheim, Calif.**

No. 295 on Reader Service Card

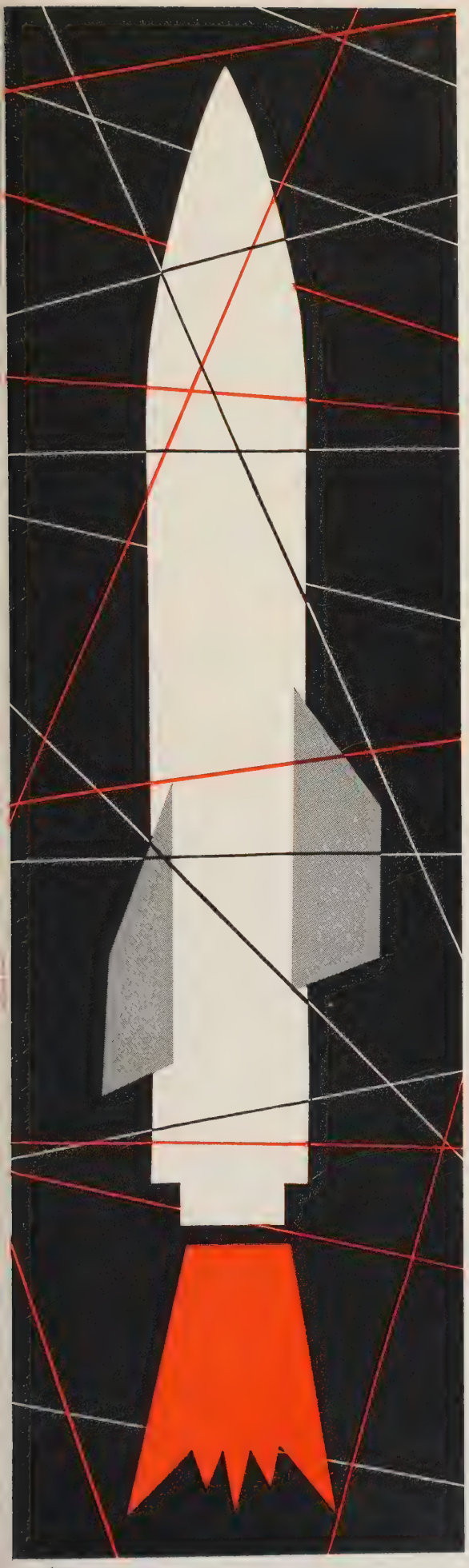
FILTER ELEMENT is pleated

This conical pleated filter element combines the advantages of reduced pressure drop and improved distribution of flow with minimum package size, says **Microporous Filter, Dept. S/A, 1537 Embassy St., Anaheim, Calif.**

The pleated element configuration provides an optimum contaminant holding area with minimum pressure drop and minimum package size. Conical element reinforcing is provided to withstand full system pressure. The unitized plug assembly is spun over to effect a perfect seal without the added weight of a separate threaded plug and O-ring assembly.

No. 296 on Reader Service Card

No. 123 on Reader Service Card



TEFLON® 100 FEP

now covered in MIL-W-16878D for military electronic hook-up wire

To electronic designers in the missile area, new opportunities are now open for improved wiring reliability. The recently issued "D" revision of Bureau of Ships' MIL-W-16878 specification for missile hook-up wire covers Du Pont TEFLON 100 FEP resin as insulation for continuous service up to 200°C.

Three constructions are included in the new spec:

Type KT—250 v. service (6-mil insulation)
Type K—600 v. service (10-mil insulation)
Type KK—1,000 v. service (15-mil insulation)

In all three types of constructions, the designer can obtain TEFLON FEP over either tin-plated or silver-plated conductors —in unlimited lengths.

In many constructions, the excellent dielectric properties of TEFLON FEP resin . . . its thermal stability . . . its low-temperature toughness . . . and its inertness to all chemicals and solvents will provide significantly increased reliability.

With this recent inclusion, FEP joins the older members of the family of TEFLON fluorocarbon resins—the TFE resins—as approved insulations meeting MIL-W-16878. Only TFE and FEP resins are permitted for thin-wall constructions under this spec.

Another military application utilizing TEFLON FEP resin is covered in MIL-C-17C—jacketing material for coaxial cable.

For more information about the properties and advantages of hook-up wire insulated with FEP resin, write to E. I. du Pont de Nemours & Co. (Inc.), Dept. SA-10, Room 2526T, Nemours Bldg., Wilmington 98, Delaware.

In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

TEFLON®
FLUOROCARBON RESINS

TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resins.

DU PONT
REG U.S. PAT. OFF.

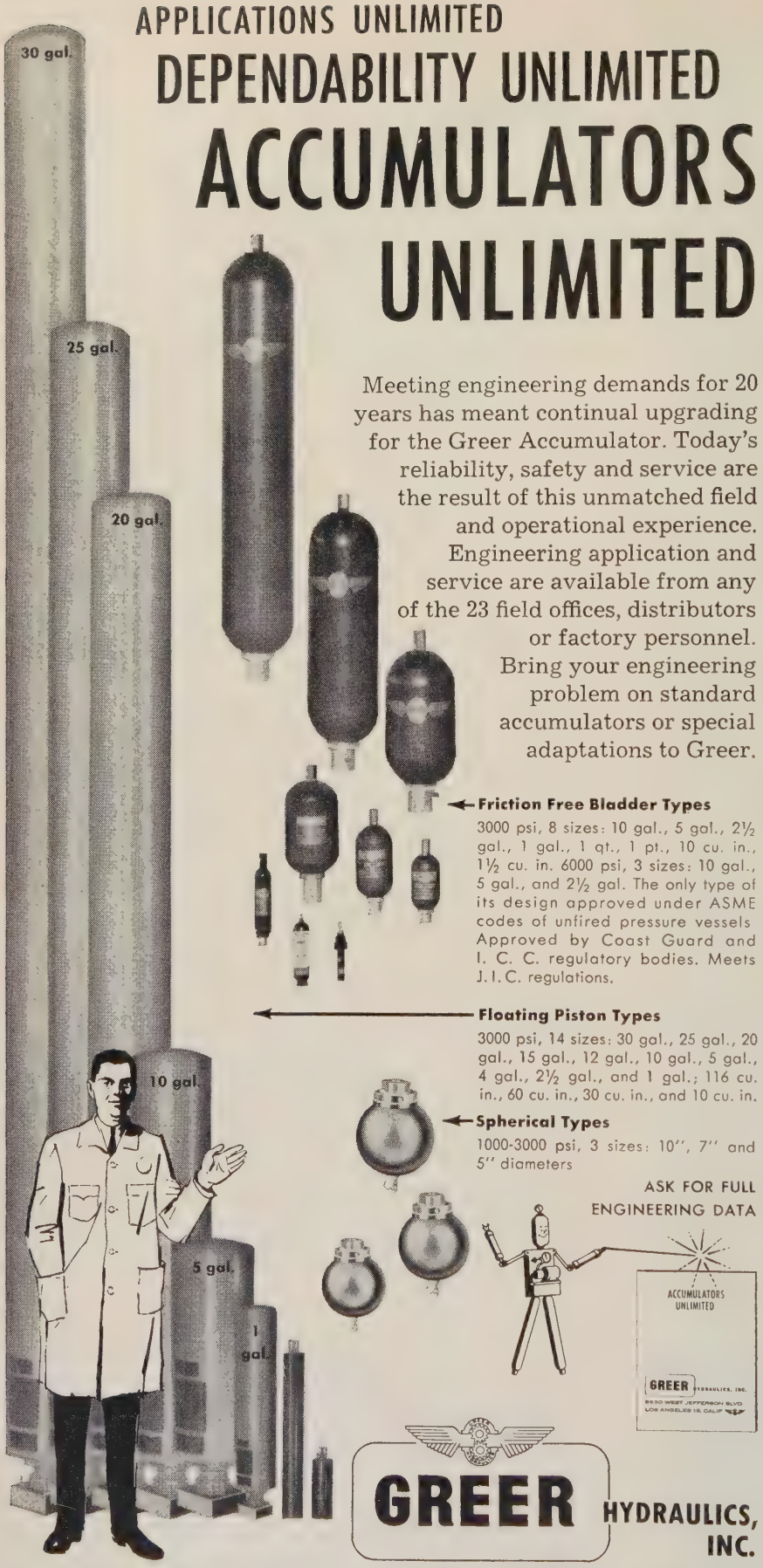
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

No. 124 on Reader Service Card

APPLICATIONS UNLIMITED

DEPENDABILITY UNLIMITED

ACCUMULATORS UNLIMITED



Meeting engineering demands for 20 years has meant continual upgrading for the Greer Accumulator. Today's reliability, safety and service are the result of this unmatched field and operational experience. Engineering application and service are available from any of the 23 field offices, distributors or factory personnel. Bring your engineering problem on standard accumulators or special adaptations to Greer.

Friction Free Bladder Types
3000 psi, 8 sizes: 10 gal., 5 gal., 2½ gal., 1 gal., 1 qt., 1 pt., 10 cu. in., 1½ cu. in. 6000 psi, 3 sizes: 10 gal., 5 gal., and 2½ gal. The only type of its design approved under ASME codes of unfired pressure vessels Approved by Coast Guard and I. C. C. regulatory bodies. Meets J.I.C. regulations.

Floating Piston Types
3000 psi, 14 sizes: 30 gal., 25 gal., 20 gal., 15 gal., 12 gal., 10 gal., 5 gal., 4 gal., 2½ gal., and 1 gal.; 116 cu. in., 60 cu. in., 30 cu. in., and 10 cu. in.

Spherical Types
1000-3000 psi, 3 sizes: 10", 7" and 5" diameters

ASK FOR FULL ENGINEERING DATA

GREER HYDRAULICS, INC.

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ANTI-BACKLASH GEAR for precision use

A custom design ideally suited for computers, navigation systems, ground control equipment, and guidance systems, this anti-backlash gear is available in stainless steel. It is a two-piece gear, spring-loaded to eliminate backlash in the mechanism. Both pieces of the gear are cut and machined together.

According to **Roi Gears, Inc., Dept. S/A, 2670 E. Walnut St., Pasadena, Calif.,** these gears offer greater accuracy in the bore and in the set between the main gear and the plate gear. Diameter and concentricities are held to 0.0002 in. tolerances, and the gear conforms to AGMA Precision Class 3. Diametral pitch is 96 or 120.

No. 297 on Reader Service Card

PRESSURE SEAL has steel spring insert

Spring loaded teflon pressure seals for cryogenic, fuel, oil, gas, and chemical applications have been developed by **Raco Engineering, Dept. S/A, 1650 21st St., Santa Monica, Calif.** It features a stainless steel spring insert which acts as a compensating pressure on the Teflon seal in temperatures ranging from —420 to 500 deg F.

The insert is said to provide initial sealing at zero pressures. As pressures increase, sealing force increases. The seal is reported extremely flexible and adjusts to out-of-round or warped flanges. It is also said to be reusable after dis-assembly and not affected by aging.

No. 298 on Reader Service Card

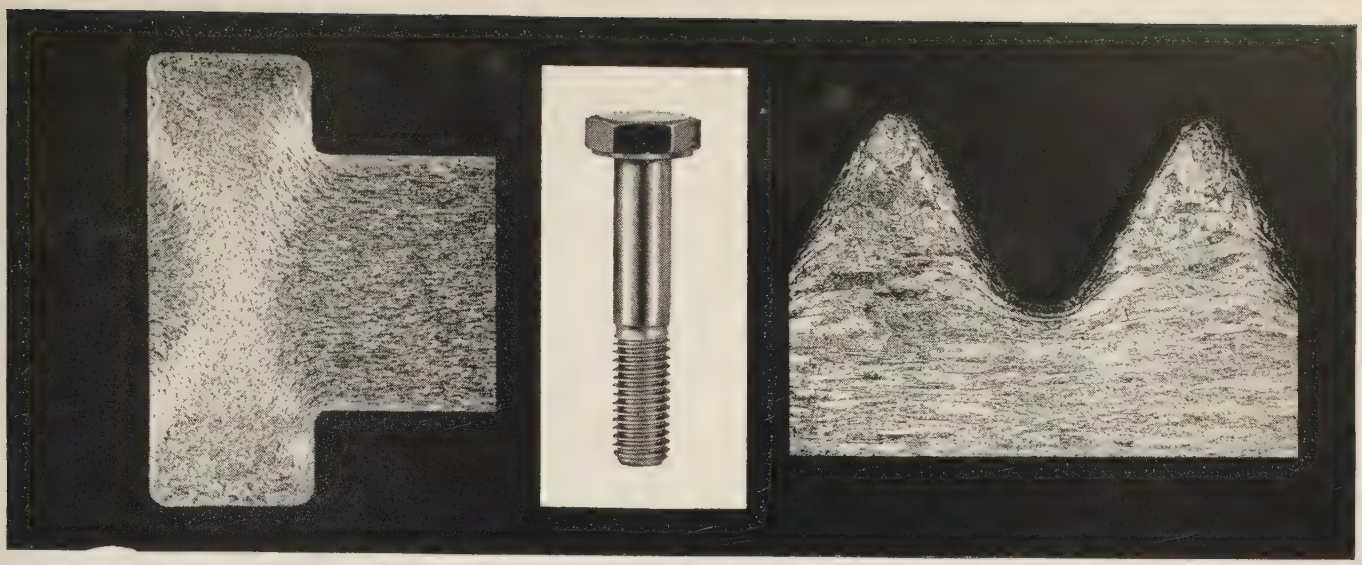
SERVO AMPLIFIER has high gain

A 100,000 gain and an input impedance of 10K ohms are available in a subminiature transistorized servo amplifier produced by **Melcor Electronics Corp., Dept. S/A, 48 Toledo St., S. Farmingdale, N.Y.** In a 1-cu in. package, it can drive a 40-volt, 2-phase servo-motor of up to 3.5 watts input.

Weighing 1 oz, this model 1037 uses silicon transistors, and operates from —55 to +125 deg C. The high gain permits use of 1 megohm summing resistors for parallel summation of multiple inputs, while maintaining a gain of 1000. Use includes potentiometer position servos, data links, and indicators.

No. 299 on Reader Service Card

No. 125 on Reader Service Card



LOOK AGAIN . . .
at this SPS tungsten bolt with **forged head** and **rolled threads!**

Rolling threads into material like tungsten is a considerable feat. Nonetheless, the sectioned bolt you see here is no mere laboratory curiosity. Rather it is one of many forged tungsten fasteners already produced by SPS for customer use and company evaluation. And you can order similar bolts in quantity today. We can furnish them in flush or hex head type, fine or coarse thread, and with *companion tungsten nuts* if desired.

The fact that only SPS can offer you these forged tungsten fasteners is indicative of SPS capabilities throughout the entire refractory-alloy spectrum. For example, take threading. Rolled threads provide greater strength, save material, assure the close tolerances necessary when working with hard-to-control coatings. Our ability to roll threads into even the most difficult refractories stems from our breakthroughs in titanium and beryllium fasteners as well as experience in producing the industry's first 300,000 psi steel bolting. And should new thread forming problems arise, we are in a position to meet them quickly through our own thread-roll die manufacturing facility.

What are your requirements in refractory-metal threaded parts? Test information, assistance with design and development, evaluation of a new alloy, collaboration on coating problems . . . let us put our highly specialized capabilities to work for you. STANDARD PRESSED STEEL CO., AIRCRAFT/MISSILE Division, SPS, JENKINTOWN 54, PENNSYLVANIA • SANTA ANA, CALIFORNIA.

SPS

where reliability replaces probability

Atlanta, Ga. • Dallas, Tex. • San Diego, Calif. • Seattle, Wash. • Tuckahoe, N. Y. • Wichita, Kans.
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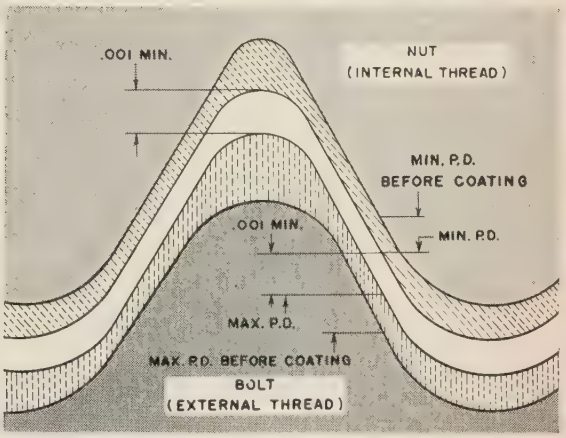


SPS radiused thread root and crest make more uniform coating possible . . . also reduce stress concentration.

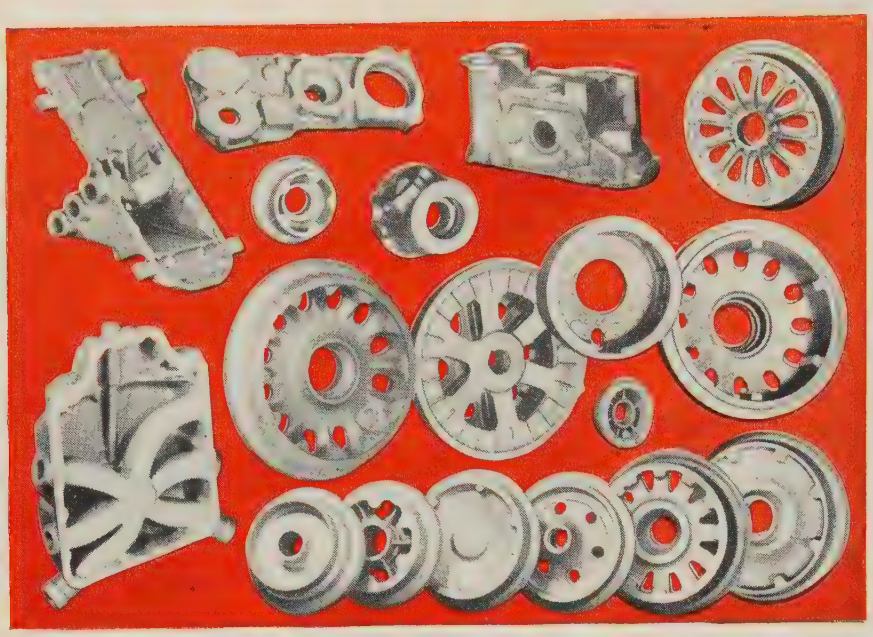
MATERIALS SUCCESSFULLY FORGED AS FASTENERS BY SPS

Columbium	Chromium	Molybdenum	Tantalum	Tungsten
Pure	Composite	Pure	Pure	Poly-crystalline
F-48	—	.5% titanium	10% tungsten	Mono-crystalline
FS-82	—	.5% zirconium	—	50% molybdenum
D-14	—	TZM	—	—

You can now obtain SPS bolts and companion nuts in the above materials. And we are constantly evaluating new alloys as they are announced.

Alloy	Test Temperature (°F)	Bolt Tensile Strength (psi)
Pure molybdenum	1800	34,400
Molybdenum—.5% titanium (sintered)	2000	50,900
Molybdenum—.5% titanium (arc cast)	2000	69,500
50% molybdenum—50% tungsten	2000	58,700
Pure columbium	2000	20,600
F-48 columbium	2000	60,000
Tungsten (polycrystalline)	2000	53,200

Tensile strengths of refractory alloy bolts tested in inert (argon) atmosphere at the SPS Laboratories for Advanced Fastener Research.



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Broad experience in military aircraft and missile programs, together with the latest in production facilities, qualifies THE A. C. WILLIAMS CO. to meet your aluminum and magnesium casting requirements in sand, shell and permanent mold.

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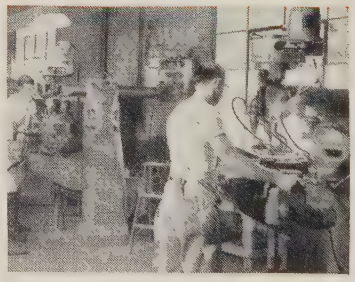


Complete and modern pattern facilities for wood or metal

Heat treating and aging . . . grinding, rotary filing, polishing . . . our own certified X-ray and Zylgo to support visual inspection . . . enable us to produce castings to your most demanding specifications.

You benefit from more than 115 years of experience in small or medium castings and from the services of our technical men which are available to your engineers at all times. Our suggestions often save money without sacrifice of performance or efficiency.

May we work with you on your problems? Without obligation, of course.

The A. C. WILLIAMS Co.

Specialists in small and medium cast iron, semi-steel, aluminum and magnesium castings.

SINCE 1844 RAVENNA, OHIO

No. 127 on Reader Service Card

TORQUE LIMIT ACTUATOR eliminates position error

This torque limit actuator has been designed to eliminate positioning error from rotary actuator applications, according to **Barber-Colman Co., Dept. S/A, Rockford, Ill.** Because travel is controlled by external stops, the actuator can be used for an infinite number of repeatable travel settings.

The unit operates up to 35 lb/in. rated load and can have a trip torque up to 45 ±5 lb./in. Speeds to 3 seconds per revolution are possible. A typical unit weighs 1.06 lb.

No. 300 on Reader Service Card

ELECTRICAL CONNECTOR uses coupling mechanism

For multiple contact configuration where high mating forces are present, this connector was an acme thread for ease of coupling, strength and vibration resistance. In addition, the ball-lock coupling mechanism is implemented to provide additional visual and blind lock inspection and the receptacles mate with push-pull plugs for quick disconnect applications.

Other design features include crimp type, insertable-removable contacts, with high temperature inserts and plating. Designated the DA series by the **Deutsch Co., Electronic Components Div., Dept. S/A, Municipal Airport, Banning, Calif.,** the connector is provided in both resilient and fused glass, hermetic insert designs and is available in a configuration containing 61 size 20 contacts.

No. 301 on Reader Service Card

AIRCRAFT WINDSHIELD is plastic

A new type of plastic aircraft windshield, developed by **The Sierracin Corp., Dept. S/A, Burbank, Calif.,** has been specified for use in the advanced turbine-powered Boeing-Vertol 107 helicopters scheduled for commercial passenger and military use. The windshields are fabricated of a hard plastic, known as Sierracin 900.

The material is used with a high-strength acrylic plastic and vinyl to make a windshield which can be made virtually impregnable to high-speed hazards such as bird impact or hail. A coating on the windshield permits electrical heating to prevent icing and fogging.

No. 302 on Reader Service Card

To fly faster than time itself...

Here's how the Douglas trisonic jet would beat the clock on westbound flights

AR. LOS ANGELES **3:30 PM**
FLIGHT TIME—1 HR. 30 MIN.*

AR. HONOLULU **7:35 AM**
FLIGHT TIME—1 HR. 35 MIN.*

AR. BANGKOK **8:50 AM**
FLIGHT TIME—1 HR. 50 MIN.*

AR. LONDON **11:55 AM**
FLIGHT TIME—1 HR. 25 MIN.*

AR NEW YORK **8:10 PM**
FLIGHT TIME—2 HRS. 10 MIN

**Includes take off and landing time.*

Trisonic jets that would land you in Los Angeles 2 hours earlier than your take-off time in New York are feasible says a late Federal study. Douglas officials say they could be operational by the early 1970's.

A 2100 mph civilian jet transport that would fly 13 miles high, cross the continent in one hour and thirty minutes*, and use present jet runways is on the drawing boards at Douglas.

Such an airplane is needed—says a recent Federal Aviation Agency study made with White House approval—to maintain U.S. leadership in commercial aviation. This is important because the export value of aircraft and parts in 1960 was $1.4 billion or 5.2% of total U.S. exports!

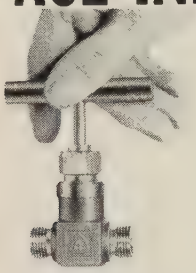
The study also notes that substantial government assistance would be needed to underwrite the $500 to $550 million estimated development costs. Douglas believes that the estimated market of 200 to 300 Mach 3 aircraft would more than repay these development costs.

They are backing this belief with continuing studies based on 15 years experience with missiles, supersonic and hypersonic aircraft...to bring the trisonic civilian jet transport to reality at the earliest possible date.

DOUGLAS

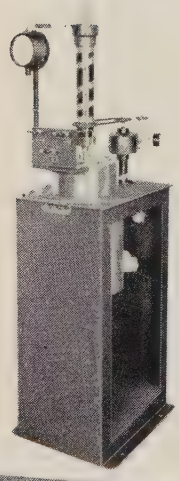
MISSILE AND SPACE SYSTEMS • MILITARY AIRCRAFT • DC-8 JETLINERS • RESEARCH AND DEVELOPMENT PROJECTS • GROUND SUPPORT EQUIPMENT • AIRCOMB® • ASW DEVICES

HIGH TEMPERATURE HIGH PRESSURE EQUIPMENT FOR THE AEROSPACE INDUSTRY



VALVES

A complete range of standard tubing valves and fittings with pressure ratings from 4,000 to 100,000 p.s.i. Special valves for high temperature and other extreme or unusual applications also are available.



PRESSURE VESSELS

Standard and special designs for laboratory, pilot plant and production operations—pressures to 100,000 p.s.i. Stirred and magnetically agitated autoclaves from 300 c.c. to 500 gallons.

PACKAGE SYSTEMS

Designed and built to your needs: package systems, complete with reactors, pumps, compressors, valving and instrumentation, for diffusion bonding, isostatic pressing, shock tube and corrosion testing.

Bulletin 1157 will acquaint you with our capabilities and service in the design and manufacture of pressure equipment. A copy is yours for the asking.

AUTOCLAVE ENGINEERS
INCORPORATED
2933 West 22nd Street • Erie, Pennsylvania

DC RELAY *is less than ½ cu. in.*

This MK series miniature dc relay, which occupies less than 1/2 cubic inch of space, is available unenclosed or in one of three dust-tight enclosures from **Elgin Advance Relays, Dept. S/A, 2435 N. Naomi St., Burbank, Calif.** Beryllium copper hinges assure stable performance and long life.

Specifications are: SPDT and DPDT contact; 1 amp res, 0.6 amp ind contact rating; 0.75 watt SPDT and 1 watt DPDT pull-in power; continuous duty cycle; −55 to +85 deg C temperature range; 51/64 x 31/32 x 5/8 unenclosed dimensions; 11 gram weight.

No. 303 on Reader Service Card

SERVO PACKAGES *have three rotary elements*

Miniature gear train servo packages having three rotary elements are available in two models from **Clifton Precision Products Co., Inc., Dept. S/A, 5050 State Rd., Drexel Hill, Pa.** Each unit accommodates ratios up to 1000:1 from the motor to the first synchro; up to 36:1 from the first to the second synchro.

The fine pitch precision gears are mounted between jig-bored plates, thus assuring maximum accuracy, says the company. Each package weighs only 6 to 10 oz, depending on materials used. The gear train is enclosed completely to insure long life.

No. 304 on Reader Service Card

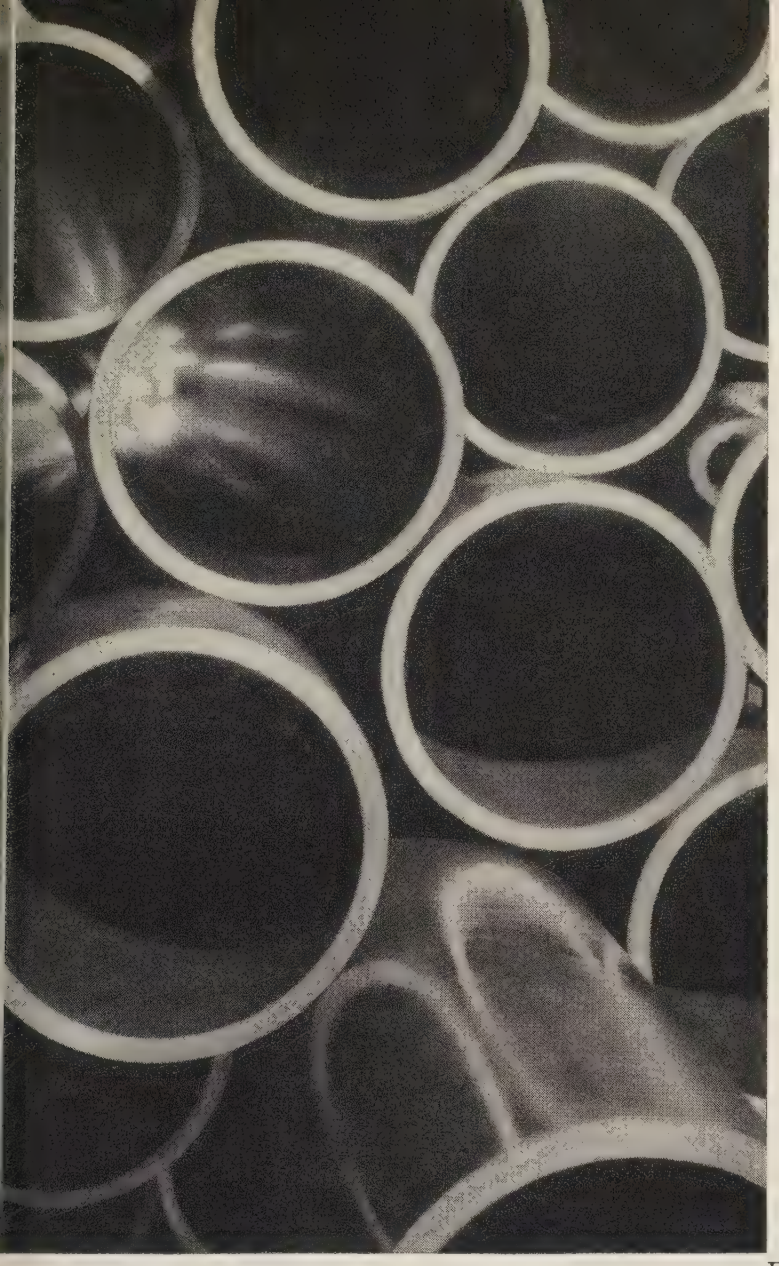
PRESSURE TRANSDUCER *is hermetically-sealed*

A new absolute pressure transducer, the Model 311, utilizes a bourdon tube for low temperature error, matched to a precision wirewound potentiometer element. Produced by **Bourns, Inc., Dept. S/A, 6135 Magnolia Ave., Riverside, Calif.**, the instrument is offered in pressure ranges of 0 to 100 and 0 to 5000 psi.

Nominal resolution is as low as 0.25 per cent, and power rating is 1.0 watt at 165 deg F. The response time of the unit is 20 msec to respond to 63 per cent of a step pressure change. Size of the instrument is 0.98 x 1.89 x 1.78 in. exclusive of connectors and mounting bracket.

No. 305 on Reader Service Card

No. 128 on Reader Service Card



This mark tells you a product is made of modern, dependable Steel.

Smooth . . . inside, outside . . . and accurate, too!

For a very fundamental reason, more and more Engineers, Designers and Purchasing Agents are specifying USS National Electric Resistance Welded Steel Mechanical Tubing—it saves money.

Dimensional accuracy and closely controlled mechanical properties insure consistency—consistently low machining losses, uniform strength, low fabrication costs and high torsion resistance—and the tubing is smooth inside and outside.

Whether your tubing application requires the dependability for a load-carrying member or the surface smoothness quality for a hydraulic cylinder, USS National Electric Welded Mechanical Tubing must be your first consideration.

USS National Electric Welded Mechanical Steel Tubing is available in a wide range of cold drawn or hot rolled sizes from as small as ⅜″ x .028″ to as large as 5½″ x .250″. Your National Tube Distributors throughout the country will gladly show you how tubing can reduce your costs. See your USS National Tube Distributor.

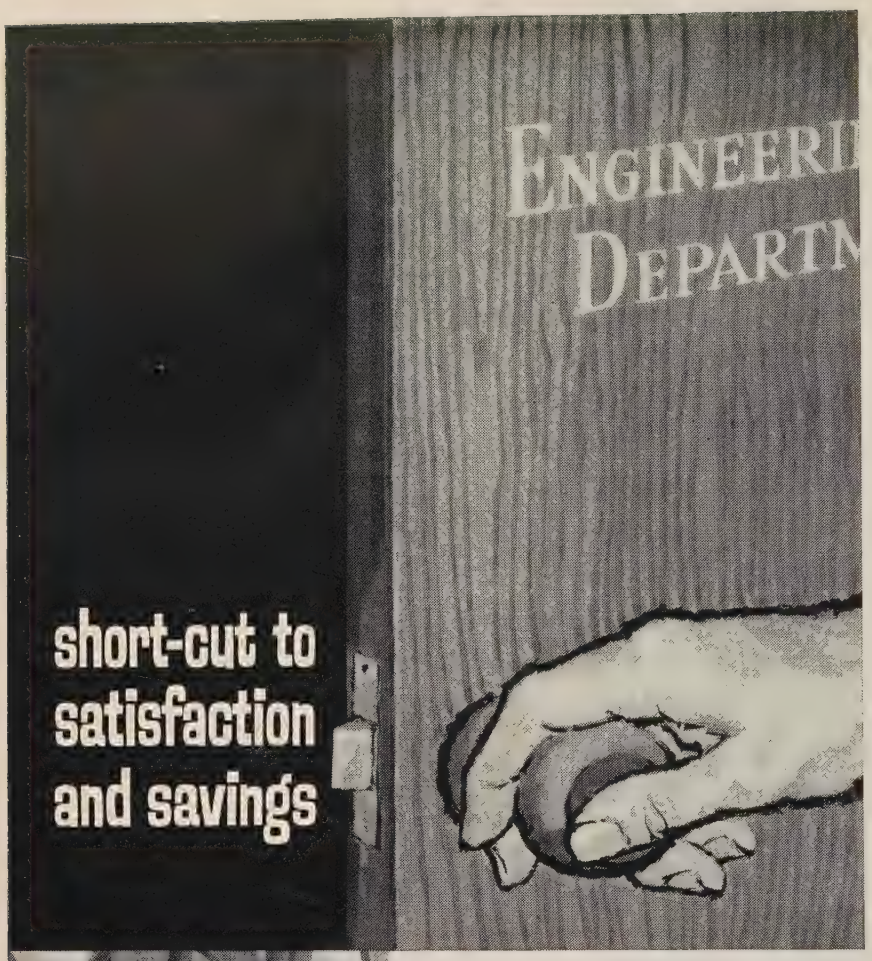
USS and National are registered trademarks

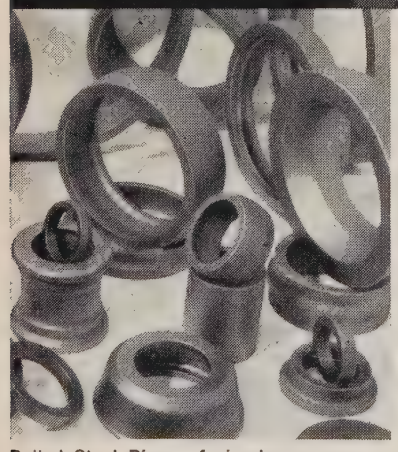
National Tube Division of United States Steel

USS

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Supply Division
United States Steel Export Company, New York

No. 129 on Reader Service Card





Rolled Steel Rings of simple or complex cross-section can be produced by the Edgewater process, in diameters from 5 to 145 inches. Materials include carbon steel, stainless and heat-resisting alloys, tool steel.

Edgewater's first step in answering an inquiry for rolled steel rings is to have Engineering check the proposed design for possible modifications that would improve the ring and/or reduce the price. This assures a good design—one that meets all requirements, at lowest cost.

Forged from solid blocks of steel and rolled on a powerful ring mill, Edgewater weldless rings are formed to cross-section shapes so close to finished dimensions that very little machining is needed. Close tolerances mean less labor, less scrap loss, lower overall costs. The Edgewater rolling process assures maximum strength, toughness and uniformity. Send drawings for recommendations and prices.

INTERESTING description of the ring-rolling process is given in this brochure, **Edgewater Rolled Steel Rings.** We will be glad to send you a copy.

Edgewater Steel Company

P.O. Box 478 • Pittsburgh 30, Penna.

PRESSURE TRANSDUCER for severe environments

A miniature low pressure potentiometer transducer that withstands 100 g acceleration with little error is available in 0 to 10 to 0 to 350 psia ranges. The compact Model L-113 contains a patented force summing mechanism developed by **Servonic Instruments, Inc., Dept. S/A, 1644 Whittier Ave., Costa Mesa, Calif.** Pressure media are contained within an aneroid capsule which is isolated from the electrical component, making possible operation in any deleterious atmosphere without adverse effect.

The unit provides exceptionally high immunity to vibration without fluid damping. Its reliabel performance characteristics are said to make it ideal for use in missile and space satellite requirements. A high level dc or ac signal output can be used without amplification for control or telemetry circuits. The Model L-113 weighs 1.7 oz and measures 1 in. diam x 1 in. long.

No. 306 on Reader Service Card

BALLISTIC THRUSTER for Mercury project

An emergency ballistic thruster has been designed for installation on Project Mercury spacecraft. The unit will be used only when conventional means of actuation have failed.

Developed by **Propellex Chemical Div., Chromalloy Corp., Dept. S/A, P. O. Box 187A, Edwardsville, Ill.,** this 2 in. long by ⅜ in. diameter unit is capable of delivery of at least 10 lb of thrust. Because its operation must be guaranteed absolutely, it is equipped with a dual electrical ignition system, with two pairs of shielded leads.

No. 307 on Reader Service Card

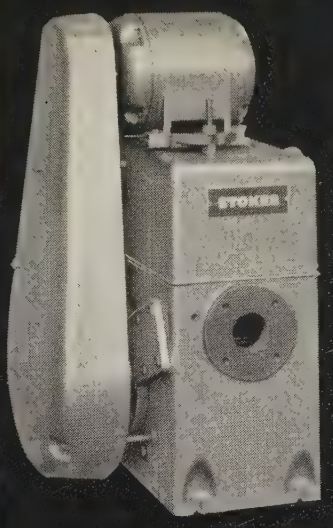
COAXIAL RELAY for 52-ohm coax lines

The CB series coaxial relay is now available for use on 52-ohm coax lines and on lines having impedance other than 52 ohms. According to **Elgin Advance Relays, Dept. S/A, 2435 N. Naomi St., Burbank, Calif.,** low standing wave ratios permit usage on frequencies up to 300 mc.

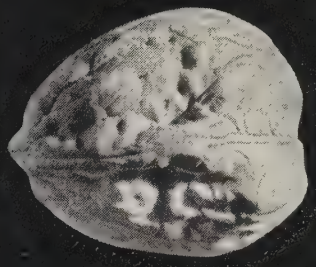
Specifications for the relays include: pull-in power—DC relay 2 watts, AC relay 8-10 va; contact rating—5 amp res, 2 amp ind; duty cycle — continuous; dimensions — 1-13/32 x 3-19/32 x 3-9/32; weight—11.1 oz.

No. 308 on Reader Service Card

No. 130 on Reader Service Card



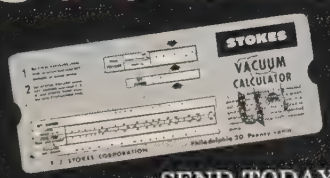
a vacuum pump as compact as a . . .



Yes, designed for compactness . . . and with no costly extras to buy. Saves up to 50% of your valuable floor space. But these are just a few of the revolutionary features of the new Stokes Series H Microvac pump.

Find out why Stokes offers you *more pumping performance per dollar*. Just write: Vacuum Equipment Division, F. J. STOKES CORPORATION, 5500 TABOR RD., PHILA. 20, PA.

STOKES



SEND TODAY for your free Vacuum Slide Calculator!

No. 131 on Reader Service Card

ACCELERATION SWITCH *is fluid damped*

This Model 18001 acceleration switch is a spring-mass, fluid damped device which may be used to open or close a circuit in the presence of acceleration. Viscous damping, using special fluids developed by **U.S. Science Corp., Dept. S/A, 5221 W. 102nd St., Los Angeles 45, Calif.**, is proportional to velocity. Contact is made by precious metal alloys resulting in contact resistance of less than 0.1 ohms. The switch is hermetically sealed and isolated against environmental extremes.

The Model 18001 in its standard configuration is a SPDT, normally open or closed switch. Standard ranges extend from 0.02 to 200 g. Optional configurations include packaging with latching or unlatching release, time delay devices, automatic checkout or programming devices.

No. 309 on Reader Service Card

THERMOELECTRIC GENERATOR *has no moving parts*

The commercial availability of an 8-watt thermoelectric generator with no moving parts has been announced by **Texas Instruments, Inc., Dept. S/A, P.O. Box 6027, Houston 6, Texas.** The units will operate from natural gas, propane, or butane.

According to TI, long term reliability has been designed into the units. Featuring ruggedized construction for efficient long-term field use, the units weigh 65 lb and are 12 x 17 inches. Other power output ranges are available in addition to the 8-watt model.

No. 310 on Reader Service Card

DATA FILE

CONTROL VALVE—A data sheet on a three-way, cryogenic, solenoid-operated, directional control valve for use with helium is offered by **The Weatherhead Co., Special Products Div., Dept. S/A, Cleveland 8, Ohio.** It gives engineering data and is illustrated with a flow chart.

No. 311 on Reader Service Card

PUMPS—Centrifugal pumps designed for movement of corrosive, toxic, and explosive fluids are outlined in a bulletin issued by **Chempump Div., Fostoria Corp., Dept. S/A, Huntingdon Valley, Pa.** The two-page bulletin lists design features, performance curves, and other specification data.

No. 312 on Reader Service Card

FIRST OPERATIONAL ICBM GUIDANCE

The Free World's first operational ICBM guidance system—General Electric's radio-command development—has proved its precision by directing the Air Force's Atlas to target—time after time after time.

It makes little difference whether the shot is 4000 miles or 9000 miles. The accuracy is always there—ready and waiting.

At the outset of the program in 1955 the original technical expectations were that an accuracy of about 4 to 5 miles was the best that could be achieved. Today radio-command guidance has improved these accuracy expectations in a complete test program carried out at Cape Canaveral.

For more information, write to Section 170, Defense Systems Department, General Electric Company, Syracuse, N. Y.

170-01A

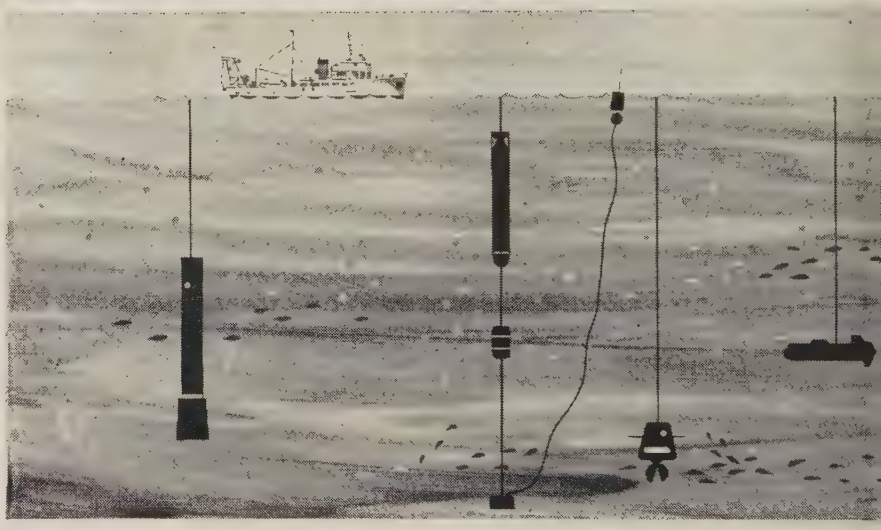
Defense Systems Department • Syracuse, N. Y.
A Department of the Defense Electronics Division

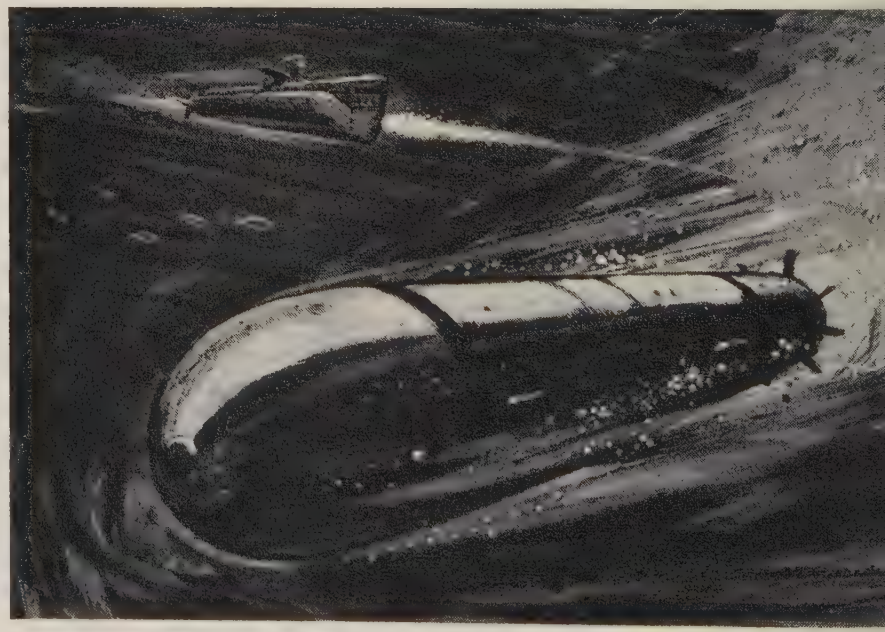
GENERAL ELECTRIC

No. 132 on Reader Service Card

THE WONDER MATERIAL FOR ASW IS PLASTICS

...AND THE COMPANY FOR PLASTICS IS ZENITH





Plastics will not corrode. It will not undergo electrolysis. It is non-magnetic. It is more difficult to detect. And reinforced-plastics has an amazing strength, even at great depths.

Zenith has the extensive engineering knowledge, well-equipped reinforced-plastics laboratories, electronic test facilities, and large production capabilities to form resin-bonded glass fiber into virtually any marine component imaginable. Zenith has more than 15 years experience in pioneering new techniques and production processes in plastics.

Zenith has developed its own method of end-over-end filament winding, a process which gives a high strength-to-weight ratio. Zenith has equipment which makes it possible to mold reinforced plastics into huge and highly complex shapes. These are the reasons Zenith has the versatile capability to produce marine components *better* in plastics. This is why Zenith was the company called on to build the first all-plastics LCVP for the Navy.

Consider the many benefits of plastics in your undersea, ASW, and marine projects before you seal the design. Remember, the wonder material for ASW is plastics...and the company for plastics is Zenith.

Minnesota Mining and Manufacturing Company

ZENITH PLASTICS DIVISION

1600 WEST 135TH STREET, GARDENA, CALIFORNIA

3M COMPANY

No. 133 on Reader Service Card

GENERAL METALS ACQUIRES AIRCRAFT PRODUCTS BUSINESS

General Metals Corporation, Industrial subsidiary of Transamerica Corporation, announced today that it had acquired the Aircraft products business of Gladden Products Corporation, Glendale, Calif.

William E. Butts, General Metals' President, said the acquisition includes lines of hydraulic and pneumatic components for aircraft and missile, the production of which will be continued from the General Metals Adel Division Plant at Burbank, California. Technical and production personnel engaged in their manufacture at Glendale will continue that activity for General Metals at the Adel Plant.

The other subsidiary companies of Gladden were not included in this transaction, Mr. Butts said.

Adel Division of General Metals specializes in the design and manufacture of hydraulic, pneumatic, fuel and electro-mechanical systems and power generating packages for aircraft, missiles, rockets and ground support applications. Butts said the combined operation will continue to specialize in these fields, offering products which have been developed through the experience of each company during many years.

During the past eighteen months, General Metals has completed the enlargement of its facilities in Houston, Texas and in the San Francisco Bay Area has integrated the Enterprise Division with its iron and steel facilities in Oakland. The Company's Enterprise Diesel Engine Division at Oakland produces Diesel Engines for stationary power plant and Marine application.

No. 134 on Reader Service Card

Propulsion and Accessory Equipment

MATERIALS—Packings, gaskets, textiles, and friction materials of special interest to aviation, missle, and spacecraft industries are described in a catalog published by **Johns-Manville, Dept. S/A, 22 E. 40th St., New York 16, N.Y.** The 28-page catalog, PK-162A, describes products that are presently functioning in applications where flame, erosion, temperature, chemical action, or high pressures are critical.

No. 313 on Reader Service Card

LOCKING DEVICE — An illustrated catalog from **Formsprag Co., Dept. S/A, 18845 W. McNichols Rd., Detroit 19, Mich.,** presents the company's Rev-Lok dual torque locking and positioning device. It describes and diagrams the Rev-Lok's components, construction, operating principles, design, installation and maintenance, and gives typical applications.

No. 314 on Reader Service Card

ACCELEROMETER—A description of design features of the Type 4-203 strain gage accelerometer is available in a two-page bulletin from **Consolidated Electrodynamics Corp., Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif.** The bulletin covers operating characteristics and environmental specifications.

No. 315 on Reader Service Card

SYNCHROS—Detailed specifications to aid in selection of synchros for servo applications are given in a data sheet issued by **Vernitron Corp., Dept. S/A, 125 Old Country Rd., Carle Place, N.Y.** Characteristics are listed for transformers, transmitters, and receiver transmitters, all engineered and manufactured to MIL-S-20708A specifications.

No. 316 on Reader Service Card

CONNECTORS—An illustrated six-page folder which describes a complete line of pin-and-socket type multiple connectors has been published by **AMP, Inc. Dept. S/A, Harrisburg, Pa.** The folder details the electrical and mechanical characteristics of the pin-and-socket connector line and lists the features of the five types of contacts available.

No. 317 on Reader Service Card

PROVEN RELIABILITY

General Electric's radio-command guidance system, the nation's first guidance for an ICBM, has been thoroughly tested and proven at Cape Canaveral. Today the system has already logged thousands of hours of operating time. And, over the last two years it has guided the Air Force Atlas missile in 33 launches without having a single in-flight failure . . . that's an in-flight reliability of 100%.

Such performance results from good basic design and a thorough preventive maintenance program. The same factors have made the radio guidance system capable of remaining on 24-hour alert, ready for launch in less time than it takes to prepare the missile.

Write to Section 170, Defense Systems Department, General Electric Company, Syracuse, N. Y., and we'll send you more facts on this proven guidance equipment for ICBM's.

170-01B

Defense Systems Department • Syracuse, N. Y.
A Department of the Defense Electronics Division

GENERAL ELECTRIC

No. 135 on Reader Service Card

36 or more
fully controllable
images
from one Kollmorgen
projector system

Ships, planes, and submarines to simulate combat maneuvers on battle terrain were required for a naval classroom training device. The problem was taken to Kollmorgen . . . and solved with a unique projector system that can produce up to 36 individual silhouettes of military warfare equipment—fully controllable at any speed, in any direction, and on any screen or wall. Depending upon design parameters, as many as 144 images or more could be provided.

The multi-image projector operates by utilizing a variable number of image projectors to cast preselected images on a screen. A separate projector system provides stationary grids or charts. Thus, images can be maneuvered on simulated battle environments by remote control.

Kollmorgen offers specialized optical/electronic/mechanical skills to meet all kinds of specialized or unconventional requirements. Write Dept. 1310.

PRESENT US WITH A PROBLEM.

KOLLMORGEN
CORPORATION
NORTHAMPTON, MASSACHUSETTS

No. 136 on Reader Service Card

Propulsion and Accessory Equipment

PNEUMATIC ACTUATORS — Pneumatic spring and diaphragm actuators are discussed in Bulletin B-1020-7 prepared by **Conoflow Corp., Dept. S/A, 2100 Arch St., Philadelphit 3, Pa.** The four-page bulletin illustrates and describes various typical combinations, specifications, operating characteristics and dimensions.

No. 318 on Reader Service Card

PROTECTIVE PAPERS—A comprehensive line of pressure sensitive protective papers is described in a two-color brochure from **Mask-Off Co., Dept. S/A, P.O. Box 585, Monrovia, Calif.** Specifications for a variety of papers are listed in a table.

No. 319 on Reader Service Card

SHOCK MOUNTS—The design features and performance characteristics of elastomeric shock mounts are featured in a publication by **Lyon Aircraft Services, Dept. S/A, 2701 No. Ontario St., Burbank, Calif.** The four-page brochure includes deflection curves, drawings and specifications.

No. 320 on Reader Service Card

ACCELEROMETER—A leaflet has been prepared by **United Aerotronics Corp., Dept. S/A, Burlington, N.J.,** on their Model 101 accelerometer. The unit features high reliability, cross sensitivity down to 1.5 per cent, sensitivity to 40 mv/g, hermetic sealing, insulated mounting, and ruggedized design.

No. 321 on Reader Service Card

CAPABILITIES—Brochure 1-61 from **United Systems Corp., Dept. S/A, 411 TWA Bldg., 1026 Seventeenth St., Washington 6, D.C.,** describes the company's capabilities as a prime contracting source for missile, rocket, and weapon systems. It details USC's facilities for design and development, production, and quality control.

No. 322 on Reader Service Card

VALVE—Pneumatic check valves for handling hot ballistic gases in ejection seats are discussed in a data sheet published by **Allen Aircraft Products Inc., Dept. S/A, P.O. Box 271, Ravenna, Ohio.** The data sheet includes dimensioned drawings and lists mechanical specifications.

No. 323 on Reader Service Card

SERIES 2500
HOLEX STANDARD EXPLOSIVE BOLTS

A NEW CONCEPT OF AVAIL-ABILITY

Select the correct explosive bolt for your application. Choose from 134 sizes, in 9 strength ratings from ¾-ton to 15-ton capacities. HOLEX' participation in many of today's most successful missile and space programs is your assurance of reliability.

FOR YOUR FILE
HOLEX' 4-page Technical Data Sheet 2500 gives complete details. Write for your copy today... Dept. C

HOLEX incorporated
Design, Development, Test and Manufacture of Precision Explosive Components.
HOLLISTER, CALIFORNIA

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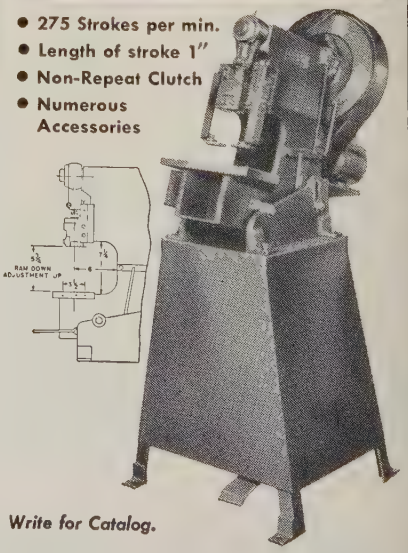
A FAST,
7½-TON PRESS
"Built for Production"
You can knock out a lot of work with
WHITNEY - JENSEN
No. 127 Inclinable High Speed
POWER PUNCH PRESS

- 275 Strokes per min.
- Length of stroke 1"
- Non-Repeat Clutch
- Numerous Accessories



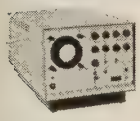
Write for Catalog.
WHITNEY METAL TOOL COMPANY
710 Forbes St., Rockford, Ill.

No. 138 on Reader Service Card

EG&G milli-mike®
INSTRUMENTS

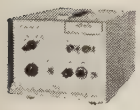
EG&G's milli-mike instruments were the first and are, by a substantial margin, the most advanced in the field of submillimicrosecond recording and measurement.

MODEL 707 OSCILLOSCOPE



DC to 2000 Mc bandwidth . . . 0.2 millimicrosecond rise time . . . single transient and repetitive signal capability . . . sensibility: 55 mv/trace width. Small spot size, maximum resolution. Six calibrated sweep speeds: 5, 30, 100, 300, 1000 and 3000 millimicroseconds/cm. Easy to operate invaluable for measurement of diode recovery time, ultra-high-frequency phenomena and in many other applications.

MODEL 751 PULSE GENERATOR



All solid-state, transistorized, high-speed pulse generator produces positive pulses of fast rise time (less than 1 millimicrosecond). Repetition rate: 10 cycles to 100 kc. Output pulse width: 2 to 100 millimicroseconds. Pulse amplitude: 20 v. into 50 ohms approx. Operable in any position. Price: $285.

MODEL 850 CAMERA SYSTEM

Optimized, fully integrated system for photographic recording of the fastest transients at 1:1 magnification.

DIODE RECOVERY CABLE SYSTEM

Model 760, a complete system for accurate observation and measurement of diode recovery time in the millimicrosecond region. Controls and meter on front panel of sturdy metal case.

PULSE INVERTERS

Model TR-6 — coaxial-ferrite balun with excellent frequency response for converting 50 ohm single-ended to push-pull 100 ohm signals. Model 819 (for use with EG&G Model 751 Pulse Generator) to provide negative pulse output.

RADIATION MEASUREMENTS

Complete systems using EG&G detectors and Model 707 Scope . . . available for measurement of high-frequency pulsed radiation.

TRANSFORMERS, POWER SUPPLIES

EG&G is outstandingly well staffed and equipped to design and produce custom-built transformers, chokes, magnetic amplifiers, DC to DC converters, pulse transformers and power supplies for military or commercial use . . . and trigger transformers for all types of flash tubes.

Full technical information on all products available on request.

Edgerton, Germeshausen & Grier, Inc.
177 BROOKLINE AVENUE, BOSTON 15, MASS.
No. 183 on Reader Service Card

Propulsion and Accessory Equipment

PLUG VALVES — Screwed end plug valves for instruments and process piping are described and discussed in Bulletin D-1 available from **Continental Mfg. Co., Dept. S/A, 230 Park Ave., New York 17, N. Y.** It provides photographs and drawings, application information, diagrams, and other general information.

No. 328 on Reader Service Card

SWITCHES—A switch catalog which provides 16 pages of quick reference data on a variety of switches is available from **Guardian Electric Mfg. Co., Dept. S/A, 1550 W. Carroll Ave., Chicago 7, Ill.** Typical items include leaf, snap-action, cam, roller, coin, bifurcated, and pushbutton switches. Complete dimensional drawings of switch components are also included.

No. 329 on Reader Service Card

ACCESSORIES — Condensed Catalog 91051 has been published by **Airmatic Valve, Inc., Dept. S/A, 7313 Associate Ave., Cleveland 9, Ohio** to describe their line of valves, cylinders, accessories, pumps, and special controls. The bulletin supplies descriptions, specifications, features, ordering data, dimensions, and a list of sales and service representatives.

No. 330 on Reader Service Card

DIAPHRAGMS — A free-positioning, constant area diaphragm for pressure sealing is the subject of a brochure published by **Bellofram Corp., Dept. S/A, Blanchard Rd., Burlington, Mass.** The brochure discusses applications, operation and outlines installation and design data.

No. 331 on Reader Service Card

INSTRUMENTS—A 12-page brochure that illustrates and describes meters for fuel position and altitude indication is presented by **The Liquidometer Corp., Dept. S/A, Long Island City 1, N.Y.** The brochure also illustrates engineering, production and quality control capabilities.

No. 332 on Reader Service Card

TRANSDUCERS — A series of data sheets that outlines specifications of pressure transducers and defines terminology is available from **Standard Controls Inc., Dept. S/A, 1130 Poplar Pl., Seattle 44, Wash.** The sheets include schematic diagrams and dimensional drawings.

No. 333 on Reader Service Card

INCREASE PAYLOAD OR RANGE

Weight savings in an ICBM—achieved by carrying only the small, lightweight equipment required for radio guidance—increase the payload carrying ability, or the range of a missile.

Only a fraction of 1% of the weight of a radio guidance system is on the missile while the rest is on the ground. Naturally, this avoids the disadvantage of having a highly complex guidance aboard the ICBM where it becomes expendable. And, a radio system's ground equipment is used over and over again.

Present day missile-borne radio guidance equipment produced by General Electric for Air Force ICBM's represents a savings of up to 470 pounds—compared with other guidance systems.

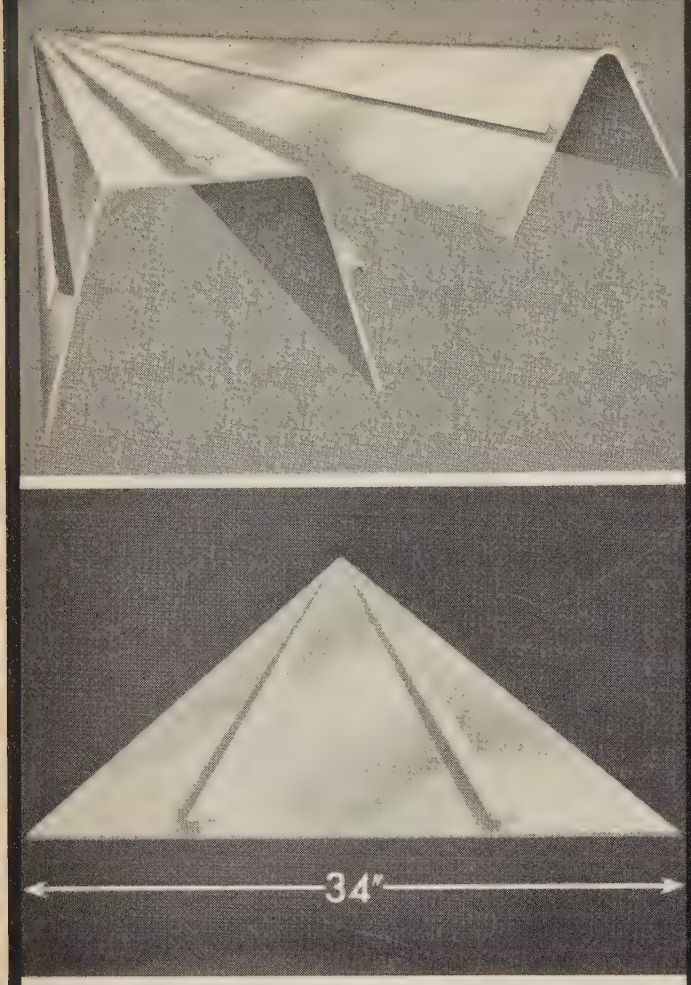
We would like to give you the full story of how General Electric's radio-command guidance system can be applied to your missile or space programs. Write to: Section 170, Defense Systems Department, General Electric Company, Syracuse, New York.

170-01C

Defense Systems Department • Syracuse, N. Y.
A Department of the Defense Electronics Division

GENERAL ELECTRIC

No. 139 on Reader Service Card



These giant panels are extruded in U-shape with three stiffening ribs, or V-shape with two (top photo) . . . then flattened to close tolerances (lower photo).

The Martin Company photo

DOW EXTRUDES GIANT 34"-WIDE ALUMINUM PANELS FOR TITAN

At Dow's Madison, Illinois, plant, a huge 13,200-ton press extrudes big aluminum panels with integral stiffeners for the Air Force Titan missile. The panels are so wide—34 inches—that they must be extruded with a "U" or "V" cross-section, then flattened and straightened. Panels with three stiffeners get the U-shape; with two stiffeners, the V-shape.

These aluminum 2014 alloy panels are flattened in Dow's contour-correction equipment to close tolerances, then straightened in a 1,000-ton stretcher.

The Dow Metal Products Company's years of large-extrusion experience include production of big parts for aircraft and ordnance equipment, as well as for missiles. Dow's Madison plant is in high-volume production of many different extruded shapes and sizes, in a wide range of aluminum alloys . . . including extrusions with circumscribing circle sizes up to 30 inches, and as long as 80 feet. For information, write The Dow Metal Products Company, Midland, Michigan, Merchandising Dept. 1102EW10.

DOW

THE DOW METAL PRODUCTS COMPANY

Division of The Dow Chemical Company

No. 182 on Reader Service Card

ACCELERATION SWITCH — Description, applications, specifications, and environmental data on Model 18001 acceleration switch are given in a product bulletin issued by **U.S. Science Corp., Dept. S/A, 5221 W. 102 St., Los Angeles 45, Calif.** Dimension drawings and photographs of alternate configurations are also included.

No. 334 on Reader Service Card

TRANSDUCER—A two-page bulletin prepared by **Consolidated Electrodynamics Corp., Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif.** describes capabilities of type 4-329 airborne pressure transducer. The bulletin lists electrical and environmental specifications.

No. 335 on Reader Service Card

BEARINGS—Four-page bulletin, published by **Marlin-Rockwell Corp., Dept. S/A, Jamestown, N.Y.,** describes a line of stainless steel ball bearings available in single-row, deep groove radial types. Complete dimensional details and load rating data are shown.

No. 336 on Reader Service Card

PLUMBING FITTINGS—A brochure covering series of lightweight fittings for missle plumbing has been prepared by **Harrison Mfg. Co., Dept. S/A, 2908 No. Naomi St., Burbank, Calif.** Included within the brochure are test data on the performance of individual components and availability of various sizes.

No. 337 on Reader Service Card

INTEGRATING GYROS — The King series of miniature floated rate integrating gyros is described in a booklet published by **Kearfott Div., General Precision, Inc., Dept. S/A, Little Falls, N.J.** A brief description, photograph, wiring and dimension drawings, and characteristics are included for the various gyros in the series. Testing information is also given.

No. 338 on Reader Service Card

VALVES—Complete details on high pressure valves and accessory fittings are contained in a 36-page catalog prepared by **Combination Pump Valve Co., Dept. S/A, 851 Preston St., Philadelphia 4, Pa.** The brochure lists standard units and outlines pertinent characteristics.

No. 339 on Reader Service Card

NOMOGRAPH—Particularly useful for rate gyros and angular accelerometers, this nomograph published by **Micro-Gee Products Inc., Dept. S/A, 6319 W. Slauson Ave., Culver City, Calif.,** makes possible rapid determination of rate and acceleration when the frequency and the displacement are known.

No. 340 on Reader Service Card

COMPONENTS—A series of brochures prepared by **The Bendix Corp., Dept. S/A, 211 Seward Ave., Utica, N.Y.,** presents details on power transmission shafts, flexural pivots, and hydraulic and injection pumps. Design features and specifications are included for each unit.

No. 341 on Reader Service Card

ACCELEROMETER—A two-axis accelerometer is the subject of a data sheet published by **Kearfott Div., General Precision, Inc., Dept. S/A, Little Falls, N.J.** The data sheets list typical characteristics, and a complete description of the unit.

No. 342 on Reader Service Card

TACHOMETER-GENERATOR—Bulletin GEZ-3313 describes the Model 2CM-9ABC-Y9 dual purpose tachometer-generator, manufactured by **General Electric Co., Dept. S/A, Schenectady 5, N.Y.** Application features and schematics plus design details are included.

No. 343 on Reader Service Card

CONTROLS—Brief descriptions and specifications are given for seventeen different types of temperature controls in an eight-page brochure issued by **Fenwal Inc., Dept. S/A, Pleasant St., Ashland, Mass.** Designed as a reference folder, it enables the engineer to request more details on the controller best suited for particular requirements.

No. 344 on Reader Service Card

COMPUTER EQUIPMENT — A complete line of peripheral equipment for their PB250 computer is covered in Catalog SP140 issued by **Packard Bell Computer, Dept. S/A, 1905 Armacost Ave., Los Angeles 25, Calif.** Included are magnetic tape units, high-speed buffer, paper tape reader, paper tape punch, card reader, digital graph recorder, converters, printers, and battery power supply.

No. 345 on Reader Service Card

UNLIMITED CHOICE OF TARGETS

With General Electric's radio-command guidance, a single missile can be preprogrammed to go to any one of an unlimited number of selected targets.

With a push of a button target selection can be changed—no need to spend hours prior to launching to change targets.

Radio-command guidance gets additional flexibility from cube acquisition and handover capabilities. This means that the guidance radar at the ground control station can lock on a signal from a missile which is already in flight, or take over the guidance of another missile from a second guidance station.

To find out more about the radio-command guidance system, write to Section 170, Defense Systems Department, General Electric Company, Syracuse, New York.

170-01D

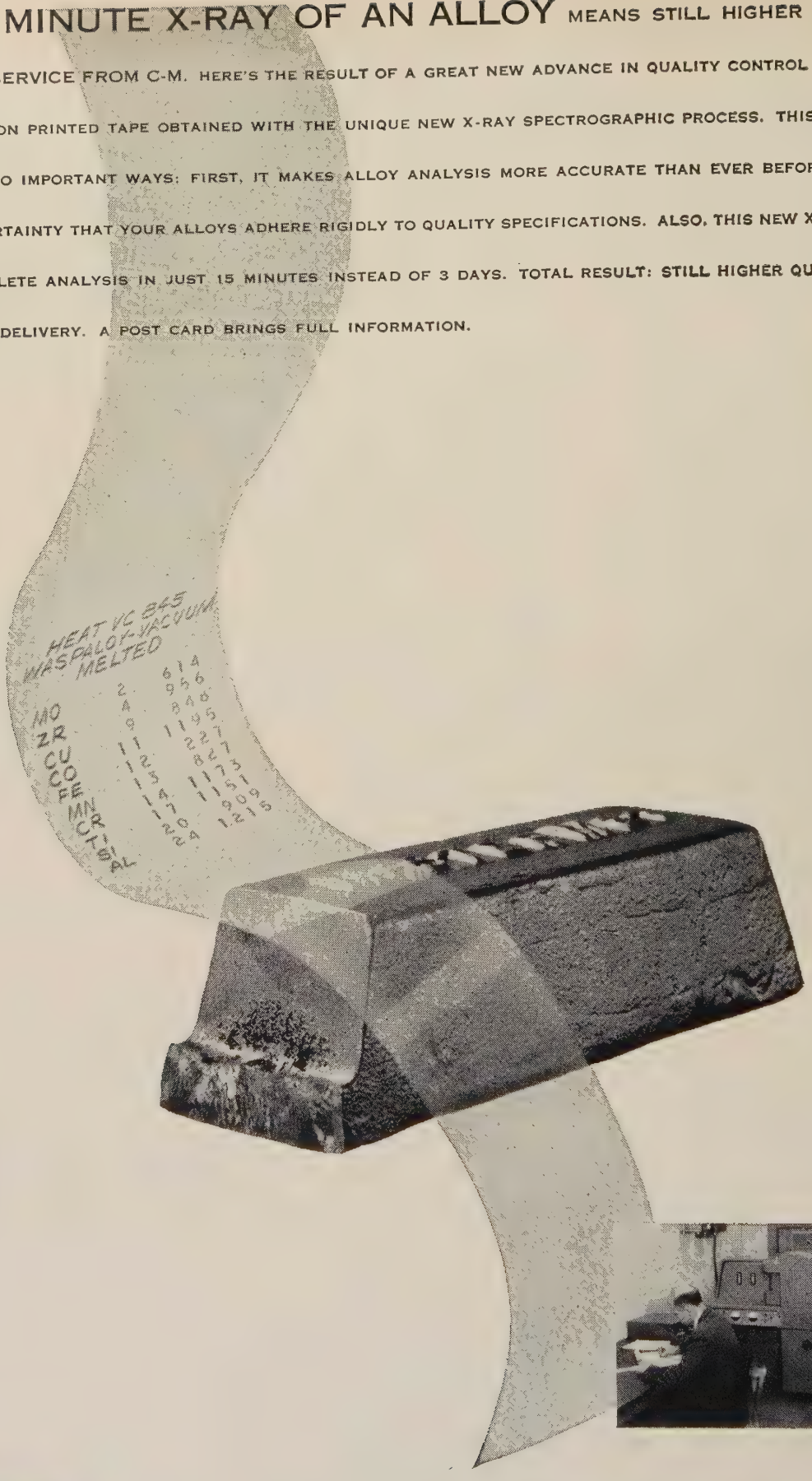
Defense Systems Department • Syracuse, N. Y.
A Department of the Defense Electronics Division

GENERAL ELECTRIC

No. 184 on Reader Service Card

NEW 15-MINUTE X-RAY OF AN ALLOY MEANS STILL HIGHER QUALITY...

STILL FASTER SERVICE FROM C-M. HERE'S THE RESULT OF A GREAT NEW ADVANCE IN QUALITY CONTROL — A COMPLETE ALLOY ANALYSIS ON PRINTED TAPE OBTAINED WITH THE UNIQUE NEW X-RAY SPECTROGRAPHIC PROCESS. THIS NEW METHOD BENEFITS YOU TWO IMPORTANT WAYS: FIRST, IT MAKES ALLOY ANALYSIS MORE ACCURATE THAN EVER BEFORE . . . WHICH MEANS ADDED CERTAINTY THAT YOUR ALLOYS ADHERE RIGIDLY TO QUALITY SPECIFICATIONS. ALSO, THIS NEW X-RAY PROCESS MAKES THE COMPLETE ANALYSIS IN JUST 15 MINUTES INSTEAD OF 3 DAYS. TOTAL RESULT: STILL HIGHER QUALITY, BETTER SERVICE, FASTER DELIVERY. A POST CARD BRINGS FULL INFORMATION.



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METALLURGICAL SPECIALISTS • 2897 LINCOLN AVENUE • MUSKEGON, MICHIGAN

PRODUCERS OF IRON, NICKEL AND COBALT ALLOYS: SHEET, WIRE, BAR, FORGINGS, INGOTS, SHO

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WHEN YOU USE

TUBINGS

TEFLON
NYLON
POLYETHYLENE
VINYL
RIGID VINYL
SILICONE RUBBER
BUTYRATE

THEN YOU SHOULD KNOW

MARKEL®

FLEXITE

When you need precision plastic tubing for fluid transfer... mechanical protection... aeronautical instrumentation... electrical insulation... or some other application... it will pay you to get samples, data and prices from Markel. Your needs may be met from the wide variety of FLEXITE tubings listed above—stocked in a full range of sizes and wall thicknesses—or we will design to your specifications. Call, write, or wire for fast action.

L. FRANK MARKEL & SONS

1 SOURCE *for* EXCELLENCE
Insulating Tubings and Sleevings
High Temperature Wire and Cable
NORRISTOWN, PENNSYLVANIA

No. 186 on Reader Service Card

Propulsion and Accessory Equipment

FACILITIES—A corporate brochure outlining the research, development and production capabilities in a range of electro-optical fields is available from **FMA, Inc., Dept. S/A, 142 Nevada St., El Segundo, Calif.** The brochure lists technical specialties and products.

No. 346 on Reader Service Card

TRANSDUCER—A description of capabilities and design features of the Type 4-350 pressure transducer is available in a two-page bulletin from **Consolidated Electrodynamics Corp., Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif.** Featuring an overpressure capability of 10 times rated range, the instrument is said to be virtually fail-proof.

No. 347 on Reader Service Card

PUMPS—"High Vacuum Vapor Pumps" is the title of Bulletin 6-1 recently issued by **Consolidated Vacuum Corp., Dept. S/A, 1775 Mt. Read Blvd., Rochester 3, N.Y.** Included in this 54-page illustrated booklet are such topics as performance characteristics, how to select a pump, special pumps and pumping systems, mechanical pumps, adapters, and pump fluids.

No. 348 on Reader Service Card

SERVOMOTOR GENERATOR—A size 8 servomotor generator with both motor and generator wound for 115-V, 400 cps excitation is described in a data sheet published by **Helipot Div., Beckman Instruments, Inc., Dept. S/A, Fullerton, Calif.** It shows photos, electrical specifications, motor dynamics, and environmental data. Outline and schematic drawings and a torque-speed curve are also included.

No. 349 on Reader Service Card

SOLENOID VALVES—A comprehensive study of solenoid valve selection for corrosive applications has just been completed by the **Valcor Engineering Corp., Dept. S/A, 365 Carnegie Ave., Kenilworth, N.J.** and is available in published form. The booklet includes a discussion of solenoid valve construction, a list of over 500 corrosive chemicals, and seven pages of valve selection charts.

No. 350 on Reader Service Card

LESS THROW-AWAYS

Since the radio-command system requires the least guidance equipment aboard a missile, it results in less expendables—that are thrown away with each launch.

In these days of soaring missile and space costs, airborne radio guidance equipment saves defense and space program dollars. General Electric's radio guidance equipment developed for Air Force ICBM's is far less complex and costs about 1/10th as much as self-contained guidance. This means that the same ground-based radio guidance equipment is re-used, launch after launch—in fact, the radio guidance facility at Cape Canaveral has logged over eight thousand hours.

Besides being very lightweight and small, radio guidance equipment aboard the missiles is also simple and reliable—consisting of two transponders and a decoder. The transponders are really little more than two-way radios that handle coded messages giving precise position and velocity readings.

To learn more about radio guidance equipment from General Electric, write to: Section 170, Defense Systems Department, Syracuse, N. Y.

170-01E

Defense Systems Department • Syracuse, N. Y.
A Department of the Defense Electronics Division

GENERAL ELECTRIC

No. 187 on Reader Service Card

Why Rocket Designers Specify HELI-COIL® INSERTS

From Redstone to Jupiter, Atlas to Thor—yes, even Freedom 7 and Liberty Bell 7—rocket and missile design has made the toughest demands on fastener engineers. To meet high shock and vibration factors, ***Heli-Coil*** Inserts are specified as an unexcelled means of protecting all tapped threads. Yet they do it in standard boss configurations with material space and weight savings over any other insert or solid bushing.

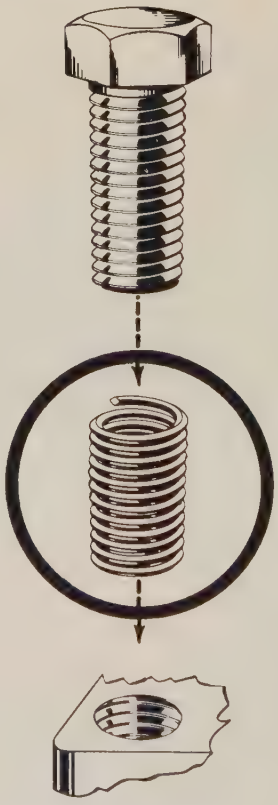
Proof? Every operational U.S. rocket, missile or space vehicle has taken aloft thread insurance in the form of ***Heli-Coil*** Stainless Steel or "Inconel X" Wire Screw Thread Inserts.

ALSO RECOMMENDED FOR MAINTENANCE

Heli-Coil Inserts have U.S. military approval and are also recommended for maintenance work, to repair stripped, worn, or damaged tapped threads. Special military ***Heli-Coil*** thread repair kits have been developed through the cooperation of contractor, military and ***Heli-Coil*** personnel. Still other kits are available for all production salvage, repair and maintenance purposes.

Whatever your material—whether ferrous or non-ferrous—even in hard or brittle materials which make the tapping of good threads difficult, installation of ***Heli-Coil*** Stainless Steel Wire Screw Thread Inserts will provide permanent, perfect, reuseable threads. They will not strip, seize, gall or corrode. And ***Heli-Coil*** "Inconel X" inserts provide these benefits, even at temperatures up to 1200°F.

Heli-Coil Design Manuals should be among your working tools. Write for your copies today. 3129



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HELI-COIL CORPORATION

110 Shelter Rock Lane, Danbury, Connecticut

In Canada: ARMSTRONG BEVERLEY ENGINEERING LTD.
6975 Jeanne Mance St., Montreal 15, Que.

LENSES—A full line of lenses for use on TV surveillance cameras, data recording cameras, and radar error measurement cameras is described and cataloged in literature available from **Wollensak Optical Co., Dept. S/A, Rochester 21, N.Y.** Included are lenses with focal lengths from 1 to 30 in., as well as their Mirrotel lenses in 20-, 40-, 80-, and 200-in. focal lengths.

No. 351 on Reader Service Card

VALVES—Designed for refinery, petrochemical and chemical processing applications, a series of globe and angle valves are illustrated in a publication prepared by **Rego Div., The Bastian-Blessing Co., Dept. S/A, 4210 W. Peterson Ave., Chicago 46, Ill.** Complete details on pressure-temperature ratings, materials, dimensions and flow characteristics are given.

No. 352 on Reader Service Card

PRESSURE SWITCH—Literature describing a leak-proof, adjustable pressure and differential pressure switch for use in fluid systems is available from **Pall Corp., Dept. S/A, 30 Sea Cliff Ave., Glen Cove, N. Y.** Bulletin E8 includes photographs and drawings of the switch with a description of its construction and operation.

No. 353 on Reader Service Card

PRESSURE-DENSITY — Two ready-reference data tables for design engineers dealing with altitude pressure and altitude density are available from **Newark Controls Co., Dept. S/A, 15 Ward St., Bloomfield, N. J.** They include specification of environmental controls for measurement and monitoring.

No. 354 on Reader Service Card

THERMOSTATS — Types A and AY snap acting fixed temperature thermostats are covered in Bulletin 3000, prepared by **Stevens Mfg. Co., Inc., Dept. S/A, P.O. Box 1007, Mansfield, Ohio.** The illustrated bulletin gives operation and construction data, as well as electrical ratings, ranges, tolerances, differentials, terminal, and attachment information. Typical applications are also given.

No. 355 on Reader Service Card

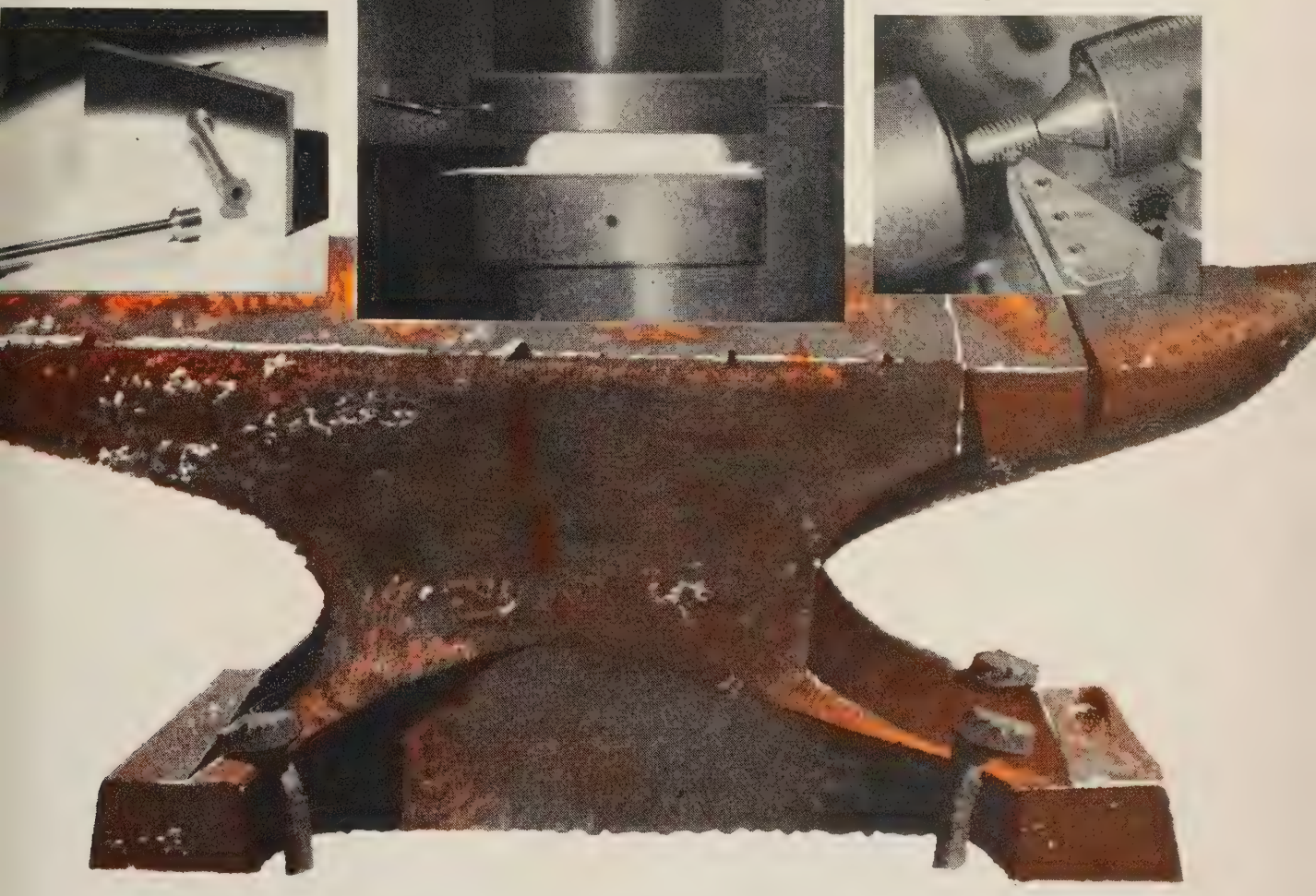
No. 188 on Reader Service Card

No. 167 on Reader Service Card

FORGE IT! Bendix Chrome Composite can be forged and hot worked.

POLISH IT! Can be given micro-surface finish by standard machines.

MACHINE IT! Can be precisely machined using conventional methods.



SEE ALL YOU CAN DO WITH BENDIX CHROME COMPOSITE

This space-age material gives unusual strength plus excellent oxidation resistance in the 2000°F. to 3000°F. range.

Bendix® Chrome Composite is ideal for use on re-entry nose caps, probes, and leading edges for another reason, too. It can be forged, hot worked, machined, and polished by conventional methods and equipment. A further advantage: it forms and reforms its own protective coating instantly when exposed to high temperatures.

For applications such as solid rocket motor nozzles—in the 6000°F. to 7000°F. range—Bendix offers Tungsten Composite. Ask for more information on these new high-temperature materials.

Bendix PRODUCTS DIVISION South Bend, IND.

THE Bendix CORPORATION

COMPACT CAPACITY

QUALITY COMPONENTS

Instant Self-Alignment . . . automatically compensates for mounting inaccuracies and constantly varying in-flight deflection of structural members, and assures full capacity available under misalignment to plus or minus 10°.

Full Radial Capacity . . . under all conditions due to rollers aligning themselves naturally, eliminating roller end wear and race surface scuffing.

High Thrust Capacity . . . without the need for auxiliary arrangements. End-thrust loading is taken on full roller contact area, not on inner race shoulders or retaining ring surfaces.

All Combinations of Load . . . are fully carried on bearing race surfaces, regardless of condition of misalignment.

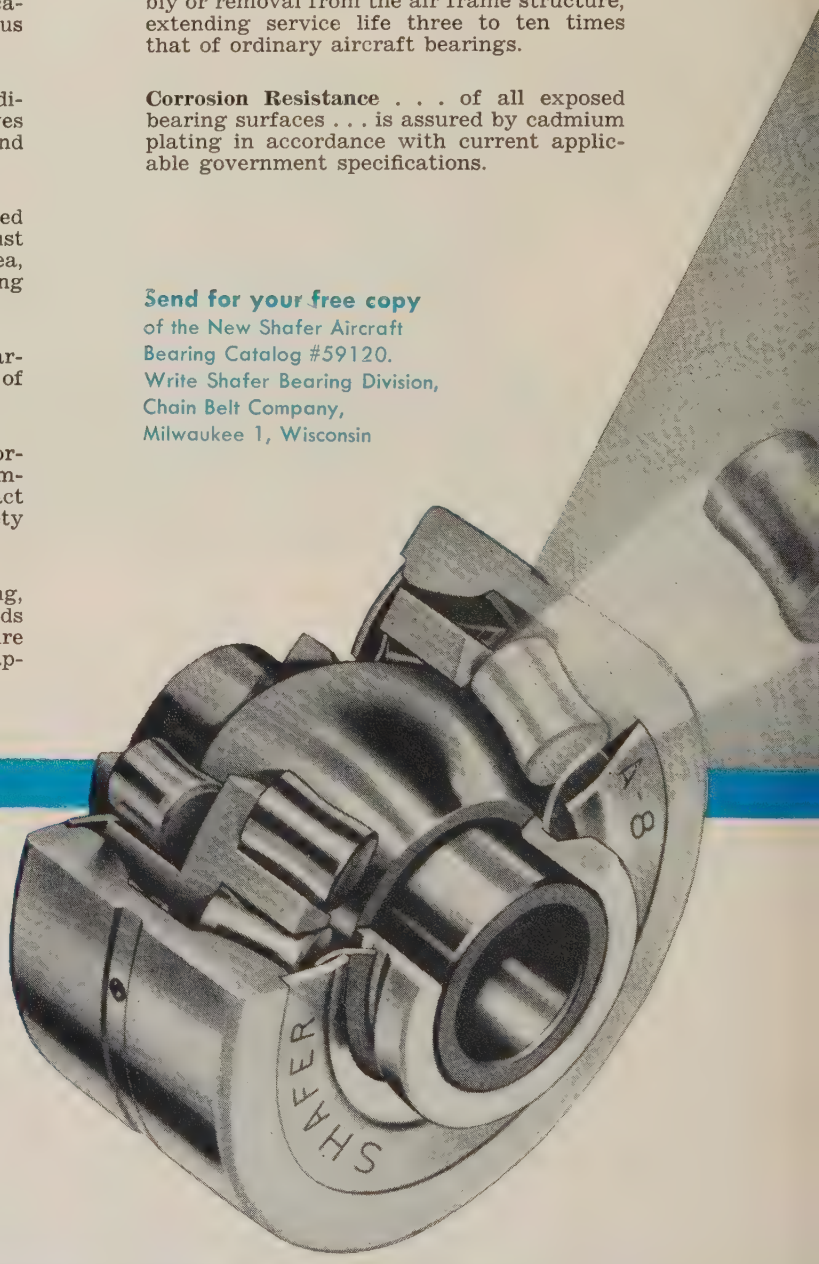
Great Reserve Capacity . . . to meet abnormal shock and impact loads . . . is accomplished by increasing length of roller contact under greater loads, providing a vital safety factor for your design.

Positive Sealing . . . by true self-aligning, free-running seals and stainless steel shields that keep lubrication in, dirt and moisture out. Special seals for high-temperature applications.

Relubrication in Service . . . is easy with all Shafer Bearings. Outer race groove design allows relubrication without disassembly or removal from the air frame structure, extending service life three to ten times that of ordinary aircraft bearings.

Corrosion Resistance . . . of all exposed bearing surfaces . . . is assured by cadmium plating in accordance with current applicable government specifications.

Send for your free copy
of the New Shafer Aircraft Bearing Catalog #59120.
Write Shafer Bearing Division,
Chain Belt Company,
Milwaukee 1, Wisconsin



SHAFER
DIVISION OF
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BELT COMPANY

Size for Size, a SHAFER Aircraft Bearing Has More Capacity and Reserve..Longer Servi

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1. **Outer Race** . . . is made of SAE-52100 electric furnace bearing quality steel, heat-treated in controlled-atmosphere furnaces to produce working surfaces that are hard and tough.

2. **Rollers** . . . are of SAE-52100 steel heat-treated to assure optimum hardness and toughness. Rollers are electronically selected by size for every bearing assembly.

3. **Inner Race** . . . like rollers and outer race . . . is made, in one piece, from high-quality SAE-52100 steel heat-treated for normal service up to 300° F.

4. **Sleeve** . . . is heat-treated to provide a tensile strength of over 150,000 lb. per sq. in.

5. **Retainers** . . . for standard double-row Shafer Bearings . . . are die-cast Zamak or Beryllium Copper.

6. **Collars** . . . of high-tensile-strength steel . . . serve as spacers for inner race and alignment stops, preventing seal damage.

7. **Seals** . . . are Buna-N in all standard series, designed to permit relubrication of bearing without seal removal.

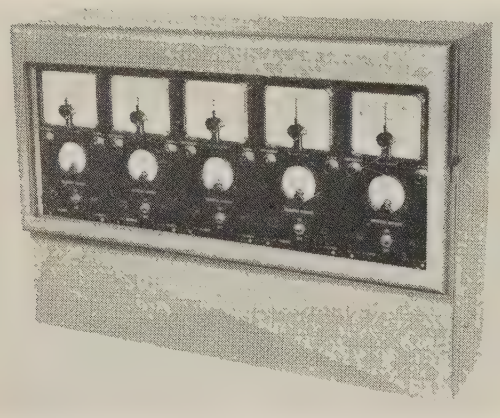
8. **Shields** . . . contour-formed of stainless steel . . . provide extra seal protection for lubricated bearing surfaces.

reater than Any Other Bearing of Equal Weight and Envelope Dimensions

DESIGN DEVELOPMENTS

For more details on the equipment, processes, and facilities described in this section write in item n

MULTI-POINT MONITOR WARNS OF GAS HAZARDS



The presence and amount of hazardous combustible gases can be detected and monitored at distances of up to 1500 ft by the Model 520 Multitector. Developed by Houston Instrument Corp., Box 22234, Houston 27, Texas, the unit monitors on up to five channels. Each detection channel includes a sensing element located at the point being monitored and connected to the central monitor by cables. At the Multitector, each channel includes a measuring circuit, indicators, and an adjustable alarm.

When a gas is present, a meter reading shows it in percentages of the lower explosion limit. If the gas concentration exceeds a predetermined safe value, both alarm and shutdown circuitry are actuated. Being self-operating, each channel is "on-duty" all the time. **58**

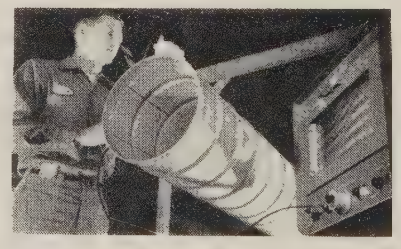
Micrometer Accuracy with Ultrasonic Thickness Gage

Ultrasonic resonance can now be used to make non-destructive thickness measurements to micrometer accuracy.

The Vidigage*, made by Branson Instruments, Inc., 40 Brown House Rd., Stamford, Conn., can take readings even when access to only one side is possible. Therefore, the company claims, thickness of tubing, large sections of sheet metal, hollow cylindrical parts, aircraft wings, and fuselage sections can be determined at any precise location desired.

The gage can make measurements from 0.005-2.7 in., within accuracies of 0.1 per cent. Even more accurate readings are possible with automatic recording equipment, the company says, and thicker sections can be gaged by extrapolation.

A piezoelectric transducer converts electrical impulses into



mechanical vibrations. When the transducer is put in contact with one surface of the metal under test, inaudible sound waves, continuously varying between 0.7 and 25 mc, are sent into the metal. Returning waves are picked up by the transducer and fed back into the electronic circuit, where resonant frequencies are amplified to show up as one or more traces on a cathode-ray tube.

A calibrated scale in front of the tube permits direct reading of thickness, which is inversely proportional to the resonant frequencies. Connected to automatic control equipment, the instrument makes production even faster.

Since the Vidigage essentially measures the distance from the surface to the first discontinuity, it may also be used for detecting laminar flaws and weak bonds in clad or roll-bonded sections, and for corrosion inspection. **62**

* Registered trademark.

Test Chamber Is Accurate to ½ deg F

The liquid-CO_2-cooled Model C-106 temperature chamber is designed by Wyle Laboratories, Inc., El Segundo, Calif., for environmental simulation tests of aerospace components. It is claimed to provide fast heating and cooling, close temperature control, and versatile and economical operation.

The chamber can simulate temperatures from —100 to 500 deg F, with an accuracy of ½ deg. An electric controller is used whose resistance bulb sensor anticipates the actual set point on a proportioning basis. This method is said to insure minimum variation over the full temperature range.

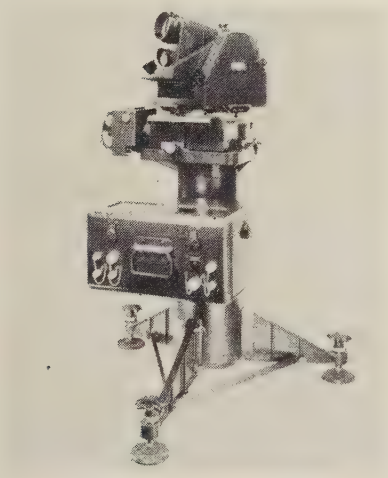
All controls, indicators, switches, and the like are located on the chamber's front panel and are clearly identified.

Designed for either rack or bench mounting, the unit will fit a standard 19-in. rack. It is 17¼ in. wide (without mounting flanges), 12¼ in. high, and 21 in. deep. Its weight is 55 lb. The overall test volume is 640 cu in. **61**

Testing and Support

Reader Service Card

Theodolite Checks Alignment to One Second of Arc



A theodolite that can measure or control the angular position of a remote object to better than one second of arc is announced by the Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn.

The company says the Model 23-210 azimuth alignment theodolite is rugged, accurate, and particularly suited for dynamic applications where the monitored device continuously changes in orientation.

The instrument automatically produces precise electrical error signals that can be used in optical-field, it can establish a precise geo correcting systems to measure angular deviations, or in closed-loop servo systems to maintain predetermined angular positions. In the graphical azimuth orientation fo the monitored object, and then continuously and automatically monitor deviations in alignment.

The heart of the device is the Barnes PEAC photoelectric autocollimator. which uses a single light source and a single detector. Its null-position response is unaffected by changes in component operation or environmental conditions. Its features include a built-in telescope for small or remote targets and an optical micrometer for zeroing the instrument and making angular measurements.

The Model 23-210 comprises, besides the autocollimator, a rotary table for setting azimuth angles to an accuracy of one second, an elevation mechanism for directing the autocollimator axis along slant paths from 20 deg above to 10 deg below the horizontal, a nadir-viewing telescope for sighting ground points directly below the rotary table's axis of rotation, and an electronics unit. **59**

SHOCK CALIBRATION offered to 15,000 g

A shock calibration service to 15,000 g is being offered by **Endevco Corp., Dept. S/A, 161 E. California Blvd., Pasadena, Calif.** Endevco offers to calibrate any piezoelectric accelerometer weighing less than 2 oz, regardless of manufacture. If associated electronics are included, a system calibration is offered.

The service includes calibration for shock and sinusoidal excitation, calibration throughout a temperature range, high g-level calibration, and cross axis sensitivity calibration.

No. 356 on Reader Service Card

GYRO TEST TABLE has two-servo-motor drive

Production of the CO56425015 precision miniature gyro test table has been announced by **Kearfott Div., General Precision, Inc., Dept. S/A, 1150 McBride Ave., Little Falls, N.J.** It consists of a precision servo table, a tilting and positioning mechanism, autocollimator and optics, and rigid mounting base.

Features of the unit are specially processed aluminum housings, two-servo-motor drive, ultra precise roller bearings, and a mounting base polished to flatness equal to a surface plate.

No. 357 on Reader Service Card

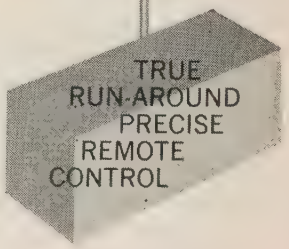
PACIFIC

Packaged

CABLE

CONTROL

SYSTEMS



To meet the exacting requirements of controls in today's high performance aircraft and engines—Pacific Scientific has developed "packaged cable control systems."

A complete run-around cable system provides the finest controls for aircraft. The many features and advantages of a properly designed and true run-around cable system can now be incorporated into component packages. This permits installation and application in many mechanical remote control functions and adds the inherent advantages and reliable performance of precise cable control.

Packaged cable control systems are logical outgrowths of Pacific Scientific Company's extensive experience in the field of mechanical control systems and components. Their flexibility can be used advantageously in both straight runs and circuitous routing. Modular construction permits easy installation to flexible mountings, structural members and pressure bulkheads.

Pacific engineers will design a component package to fit your specific control system needs.

Write for complete information today!

PACIFIC SCIENTIFIC COMPANY

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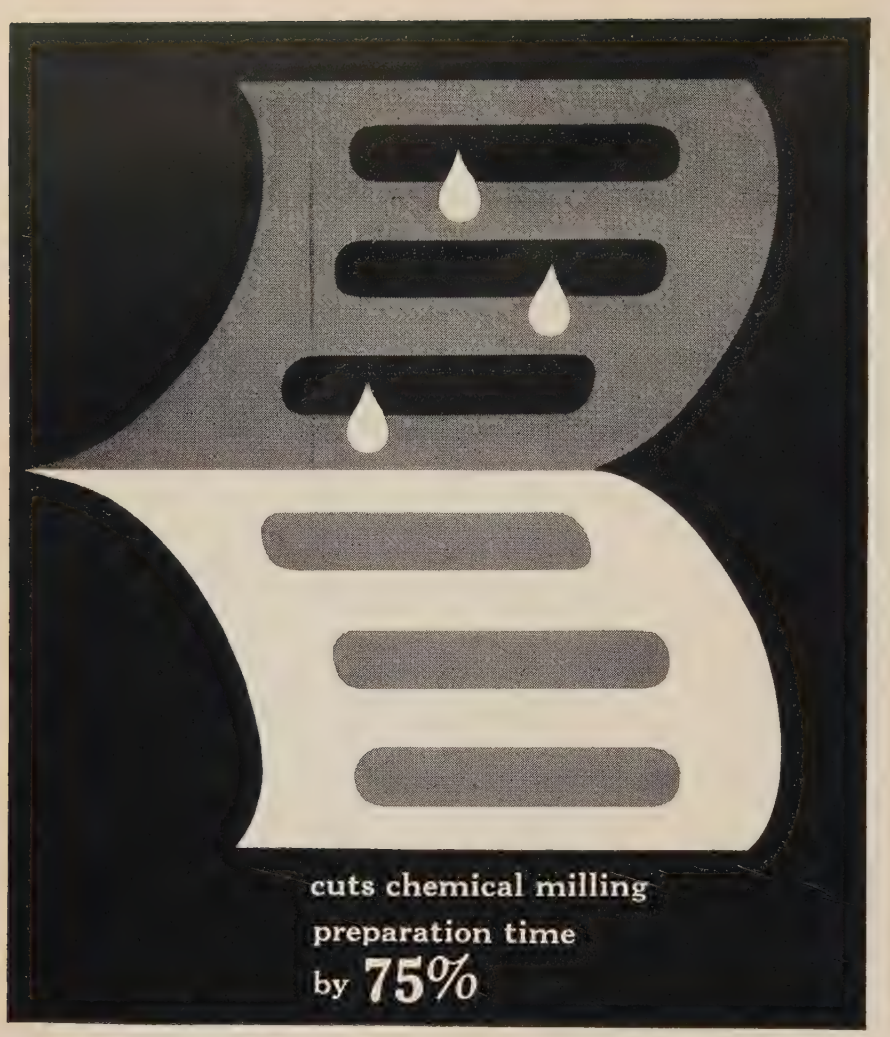
San Diego • Seattle • Portland
Denver • Arlington, Texas

Representatives in Eastern U. S.:
AIRSUPPLY-AERO CO.
In Canada: GARRETT MFG. LTD.

No. 190 on Reader Service Card



MYSTIK BRAND

7300 MYLAR MASKING TAPE

■ Here is a pressure-sensitive tape that will save time and money in your chemical milling operations. Mystik No. 7300 Mylar tape is quickly and easily applied to the surface to be masked off, and can be put on in ¼ of the time it takes to mask by spray-coating. No. 7300 not only saves valuable time, it allows for pin-point milling accuracy. The reason is the tough silicone adhesive. It grips ferrous and non-ferrous metals tightly during the entire milling process and shows excellent resistance to etching solutions. Thus, accurate milling is assured, right to the masked edge.

Get full facts on how Mystik No. 7300 Mylar tape can save you time and money, and give you greater milling accuracy. Write us today about No. 7300 and the full line of Mystik Brand Tapes.

MYSTIK® TAPE SELF-STIK

MYSTIK ADHESIVE PRODUCTS, INC.
2635 N. KILDARE AVENUE • CHICAGO 39

TIME CODE GENERATOR for flight tests

Model ECCO 802 M2 time code generator to generate precision instrumentation timing signals identical with those produced on the Atlantic Missile Range has been developed by **Electronic Engineering Co., Dept. S/A, 1601 E. Chestnut Ave., Santa Ana, Calif.**

Code in the AMR 17-bit, 24-hour binary format can be used to check out ballistic missiles and space vehicles. The unit can be switched to generate any one of three AMR code pairs. It also contains a switchable pulse rate output which furnishes one of four AMR auxiliary rates. It supplies a 1-pps positive pulse for WWV synchronization.

No. 358 on Reader Service Card

TEST STAND checks missile power

A test stand for automatically testing high pressure accumulator type hydraulic power sources on missiles has been announced by **George L. Nankervis Co., Dept. S/A, 15300 Fullerton Ave., Detroit, Mich.** Operation and sequencing of this unit are completely automatic and test results are graphically recorded for certification.

Prior to an actual run, the accumulator is pre-charged to 7000 psi from a built-in helium booster and filled with hydraulic oil. The helium charge is then released through a regulator into the accumulator bladder, forcing out the oil. During test, instruments record helium temperature, pressure in and out of the regulator, discharge oil pressure, and flow.

No. 359 on Reader Service Card

TEMPERATURE CHAMBER meets test specs

This temperature-humidity chamber, manufactured by **Wyle Laboratories, Dept. S/A, El Segundo, Calif.**, is reported to comply with the majority of test specifications in electronics, missile, and aerospace applications.

The standard unit produces relative humidities from 20 to 95 per cent at dry bulb temperatures from 35 to 200 deg F, at 35 deg F dew point. A single stage freon refrigerator dehumidifies and a steam generator produces the required humidity. Dry heat is furnished by electrical resistance. Three standard sizes are available—8, 27, and 64 cu ft.

No. 360 on Reader Service Card

No. 191 on Reader Service Card

This push-pull coupling can handle 10,000 psi

An easy "push" to connect and "pull" to disconnect is all it takes to operate the new Deutsch high-pressure fluid and gas coupling. No twisting or tricky lock movements are necessary. Here then is an effective design that can be specified for a variety of remote, umbilical, modular, or rack-and-panel applications. Safety at high operating pressures is assured by a color ring that provides visual inspection for positive lock.

And both coupling halves exceed all requirements of MIL C-25427 for fluid loss, pressure loss, air inclusion, and physical shock. Temperature range is −200°F to +450°F.

To obtain complete technical information on this advanced specification fluid and gas coupling, write today for Data File S-10

DEUTSCH

HYDRAULIC COMPONENTS DIVISION P. O. Box 73335 • 7000 Avalon Boulevard • Los Angeles 3, Calif.

No. 192 on Reader Service Card

TEST STAND for gyros

A unit to test gyros and other devices requiring precise orientation or rotation has been announced by **Kearfott Div., General Precision, Inc., Dept. S/A, 1150 McBride Ave., Little Falls, N.J.** Designated the Tumble Rate Test Stand, it features rotary table locking to permit selection of 0, 90, 180, and 270 deg static angular positions.

Typical data are: rotation rates of 150 and 300 deg/hr; table rate stability of 0.2 percent; axis wobble of 10 arc sec (max); tilting range of +90 degrees; power requirements of 115 volts AC, 60 cps, 1 phase at 15 watts —28 volts DC, 0.52 amp.

No. 361 on Reader Service Card

PORTABLE COOLER for guidance checkout

A portable liquid chiller, designed for factory test and checkout of electronic guidance packages, has been developed by **Advanced Structures Div., Telecomputing Corp., Dept. S/A, P.O. Box 150, Monrovia, Calif.** The unit comprises a refrigeration unit, coolant heat exchanger, coolant reservoir, pump, valves, controls, and instrumentation.

This AS model 141 cooling package delivers a coolant flow at between 0.2 and 1.6 gpm, and maintains a temperature setting of ±1 deg F over a range of 32 to 80 deg F. Cooling load is variable from 100 to 2700 watts.

No. 362 on Reader Service Card

RECORDER SYSTEM for preflight checkout

Automatic checkout and digital data recording systems for pre-flight checkout and developmental test facilities are now available from **Monitor Systems, Inc., Dept. S/A, Fort Washington, Penna.** This Series 7000 system uses building block technique throughout.

The systems can be used to scan any variable that is reducible to electrical form with accuracies to 0.01 per cent. Inputs from various types of primary instruments can be scanned and converted to digital form for readout in any format desired, says the company.

No. 363 on Reader Service Card

SERVO ANALYZER has combined function

This Model SV-1 servo analyzer combines a multiple function precision signal generator and an oscilloscope as a single unit. The unit determines the phase, transient and amplitude response of a servo system by generating an output signal which is applied to the servo input, and comparing a reference signal with the return signal from the servo.

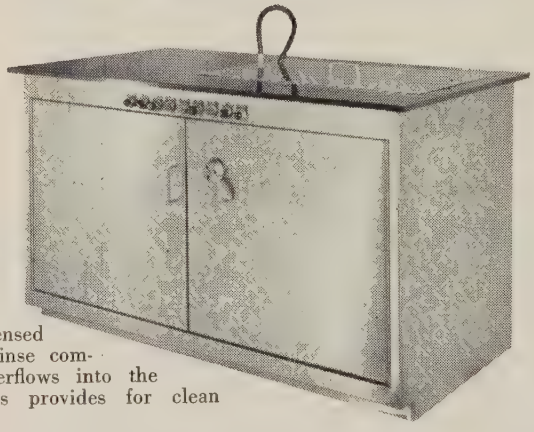
Special features of the unit, which is available from **Polarad Electronics Corp., Dept. S/A, 43-20 34th St., Long Island City, N. Y.,** include: modulation frequency rate accurate to within two per cent of set value over full frequency range; frequency range of 0.0005 to 100 cps (in five ranges); test functions including sinusoidal test signals, transient response, and bowtie pattern; oscilloscope with identical X and Y amplifiers; phase indicated directly on calibrated dial; and independent operation of oscilloscope.

No. 364 on Reader Service Card

for critical "white room" missile component cleaning applications

Blakeslee Freon® Solvent Degreasers

Water cooled condenser assures even vapor line



The BLAKESLEE patented split water jacket at the vapor line condenses the Freon® vapor, limiting solvent loss to the atmosphere. The condensed solvent is returned to the rinse compartment which in turn overflows into the boiling wash chamber. This provides for clean solvent in the rinse tank.

Work can be dipped into the boiling solvent to forcefully remove impurities, then rinsed in cooler solvent and then a final rinse in the vapor for additional cleaning and drying. A hand spray is also provided for work requiring a spray for complete cleaning. Either the rinse tank or the boiling wash tank can be filtered. Spray is also filtered.

All functions, including draining to an out-of-the-room sump, are controlled from a console of pushbuttons just under the Formica® top. The cabinet doors are fully gasketed to assure cleanest possible operating conditions.
The entire cabinet and cleaning chamber interior are polished stainless steel. Special welding and polishing throughout leaves no possible flake-off or dust catching weldments. A fitted chamber cover restricts evaporation of solvent when the degreaser is not in use.

This equipment can be equipped with ultrasonic transducers and generators. The transducers can be installed in the rinse tank. The generator can be housed within the cabinet, with controls mounted below the Formica® top as shown in photographs above.

Your BLAKESLEE Representative will be glad to discuss this equipment, ultrasonic cleaning or cleaning equipment for any cleaning problem you may have. Mail coupon, today.

G. S. BLAKESLEE & CO.
Chicago • New York
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INDUSTRIAL CLEANING & FINISHING DIVISION
G. S. BLAKESLEE & COMPANY
Dept. 131A • 1844 S. Laramie Ave., • Chicago 50, Illinois
Send me more information on:

☐ Freon Degreasers ☐ Ultrasonics ☐ Standard Degreasers

Name_____

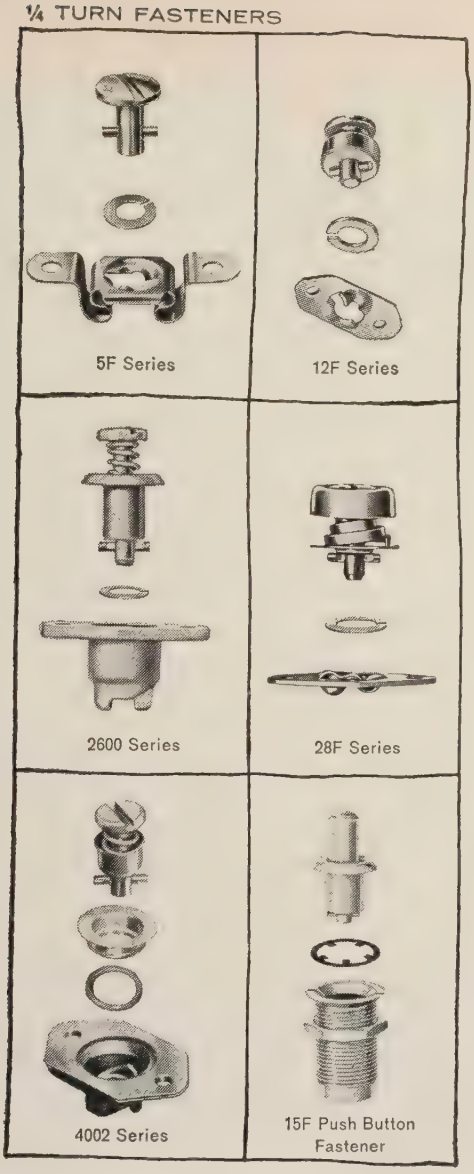
Title_____ Company_____

Address_____

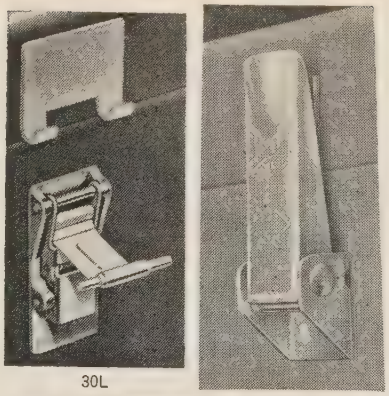
City_____ Zone_____ State_____

No. 193 on Reader Service Card

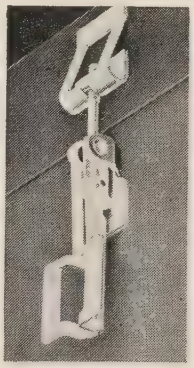
¼ TURN FASTENERS

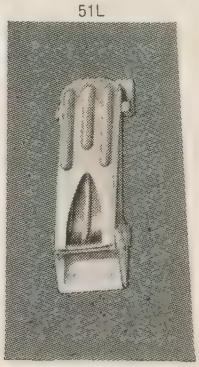


UNIVERSAL LATCHES

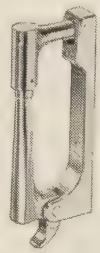

30L

51L


37L

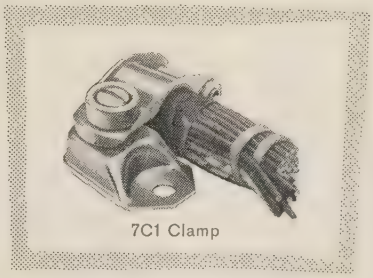

46L

CHASSIS LATCHES


21L Latch

35L Latch

HARNESS CLAMPS


7C1 Clamp

FASTEN/ATION

The mechanics of modern fastening have matured to the point where it is now considered a science. We call it FASTEN/ATION.

Your designs are important enough to build, and should be covered and protected . . . but you must be able to remove the covering in a hurry. Here's where Camloc's FASTEN/ATION becomes significant to you. Installation is simple – closure is simple – opening is even simpler, and each of these operations takes only seconds.

The final touch to a good design includes the best method of fastening, the simplest installation and use, and a fastener that complements the product in size and appearance. Since making a decision involves the evaluation of alternatives, here are some of Camloc's more popular fasteners. We know you will want to make a more careful analysis before you specify, we suggest that you write for our complete catalog. Be FASTEN/ATED! Let us FASTEN/EER your next design.

specialists in fasteners for industry

CAMLOC®

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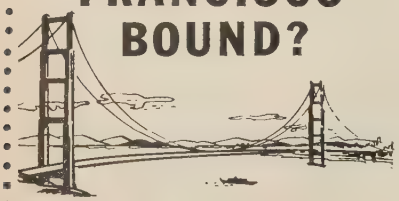
European Subsidiary: Camloc Fastener GmbH, Kelkheim/Taunus, West Germany

No. 194 on Reader Service Card

SAN FRANCISCO BOUND?



Stay at this conveniently located hotel across from Airline Bus Terminal in the heart of the city. Luxurious new rooms with TV. Colorful Pam Pam Restaurant, Regent Lounge, Connecting Garage. Rates from $7.

Group facilities to 500.

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IN LOS ANGELES:
The Beverly Carlton,
Beverly Hills—Hollywood
Plaza, Hollywood—Skyways,
International Airport

No. 195 on Reader Service Card

TEMPERATURE TESTER includes humidity

The addition of humidity to their temperature chamber has been announced by **Cincinnati Sub-Zero Products, Dept. S/A, 3932 Reading Rd., Cincinnati, Ohio.** The new chamber is available in two-, four-, and eight-cu-ft sizes, with temperature ranges from —100 to +400 deg F, and humidity from 20 to 95 per cent.

The chamber has a net test area of 14x14x14 in. Temperature and humidity are controlled by wet and dry bulb indicating controllers. The door includes a 12x12-in. frost-free multipane window.

No. 365 on Reader Service Card

HYDRAULIC TEST STAND has directional flow cycling

A hydraulic test stand, Model HC-20-5M, designed to check out and calibrate precision hydraulic components and accessories, has been announced by **Aerotest Laboratories, Dept. S/A, Comack Road, Deer Park, N. Y.**

The stand features a four-way selector valve for directional flow cycling accumulator to dampen line shock and pump pulsations, gages equipped with shutoff valves, and a reservoir with drain valve sight gage and filter. Test ranges are: flow—0 to 20 gpm at 5000 psi; pressure—0 to 5000 psi; automatic temperature control—80 to 350 deg F; hydrostatic pressure—10,000 psi.

No. 366 on Reader Service Card

FLIGHT SIMULATOR for instrument testing

A new altitude-airspeed pneumatic electronic simulator can be fed programed information from punched cards or magnetic tape to simulate flights for instrument testing purposes. Developed by the **Parker Aircraft Co., Dept. S/A, 6314 Valley Rd., Bethesda 14, Md.**, the inputs are set either manually or from remote related checkout systems.

The simulator functions with high accuracy to produce altitude pressure outputs to 80,000 ft, with hysteresis of 75 ft and repeatability of 60 ft. Airspeed pressure output is to 600 knots. This self-contained unit requires only a 110-volt ac power source for operation.

No. 367 on Reader Service Card

Looking for a standard microfilter rated up to (or above) 300 gpm?

LOOK INTO THIS FD DESIGN

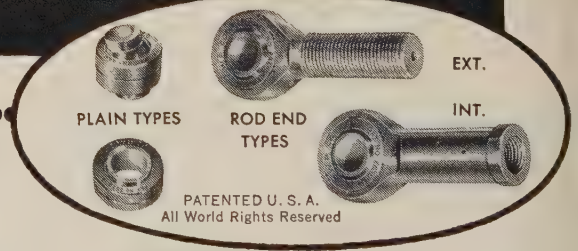
Notice (1) capacious bellied-out bowl; (2) rim-supported, reinforced element; (3) streamlined flow path. Design minimizes flow restrictions. For example, 4-inch unit handles 300 gpm (H_2O equiv. visc) with only 1 psi ΔP when removing 98% of all 40-micron particles. (Finer or coarser elements also supplied.) The ½-inch, 330 scfm unit develops only 1 psi ΔP. Dynaloy* B sintered stainless steel wire cloth element may be reinforced on both sides for flow and counter flow. Unit handles fluids from —320°F to +400°F. Minimum burst pressure, 600 psig. For detail sheet, for brochure (D-5), please write. *Trade name of FLUID DYNAMICS Incorporated

FD® FLUID DYNAMICS INCORPORATED

Dept. SA-10, 90 West St., New York 6, N. Y.

No. 196 on Reader Service Card

SOUTHWEST "Monoball" SELF-ALIGNING BEARINGS



CHARACTERISTICS

ANALYSIS	RECOMMENDED USE
Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.
"Dyflon"® Plastic Alloy Inserts. CRES Ball and Race. Chrome Alloy Steels.	For types operating under rotational, high radial loads and long cycle life where lubrication is impossible.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Our engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. Write for Engineering Manual No. 551. Address Dept. S/A 61.

SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

No. 197 on Reader Service Card

GENERAL ELECTRIC

LMED

. . . LEADER IN AERO/SPACE ELECTRONICS

THERMOPLASTIC RECORDER/DISPLAY SYSTEM

Ground-level detail projected to vehicle for immediate use

At 40,000 feet and higher a pilot could spot ground-level targets no larger than a tank by using a new recorder/display system developed by General Electric's Light Military Electronics Department. A photographic view is obtained from side-looking radar, recorded on thermoplastic tape, and displayed instantly on a screen in the cockpit. Requiring no cathode ray tube, the screen has variable brightness that permits operation in ambient light, without the use of a hood.

At extreme heights—or in space—the system is capable of providing great detail and a permanent data record of TV, infrared, or any other "eyes" of the vehicle. Combined or composite displays are also possible for integrated display applications. The thermoplastic recorder/display system is a typical example of LMED contributions to progress in aero/space electronics. 150-07

GENERAL ELECTRIC

Light Military Electronics Department

Utica, New York

No. 198 on Reader Service Card

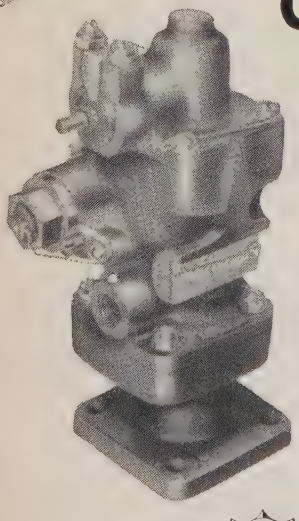
TRANSISTOR TESTER for in-circuit use

This transistor tester is reported to be capable of measuring AC Beta to ±5 per cent. The instrument, introduced by the **Hickok Electrical Instrument Co., Dept. S/A, 10514 Dupont Ave., Cleveland 8, Ohio,** uses a test method which neutralizes circuit impedance before tests are made. Hickok says that this neutralization nullifies the loading effects of external circuit impedance, thus eliminating inherent test inaccuracies.

Using an AC-bridge principle, with the transistor input elements as one arm of the bridge, the total impedance is nulled. It is claimed that, with circuit impedances as low as 150 ohms, this effectively removes these elements from the circuit as a factor in the Beta measurement. The tester measures AC Beta, I_c, transistor input resistance and base emitter circuit impedance, as well as AC Beta, I_e and I_{cbo} out of circuit.

No. 368 on Reader Service Card

Co-pilot into space



The U. S. Air Force's X-15 hypersonic manned rocket ship is flashing into space with a dependable "co-pilot" on board. A Woodward variable speed governor is charged with the vital duty of controlling the speed of the fuel pumps on the Reaction Motors' XLR99 rocket engine — maintaining correct engine speed over extreme ranges of temperature, atmospheric pressures and acceleration rates.

Woodward governors are ready to play many more significant roles in man's conquest of space. Over 90 years' experience in the governor field is applied to every prime mover control problem. Write Woodward today for expert consultation or further information.

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ROCKFORD, ILLINOIS
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WOODWARD SERVICE

"World's oldest and largest manufacturer of prime mover controls exclusively"

S-110

ANTENNA TESTER has direct-reading scales

An antenna tester featuring direct-reading scales which give all answers in numerical values is now available from **Seco Electronics, Inc., Dept. S/A, 5015 Penn Ave. S., Minneapolis 19, Minn.** This model 520 tester is made for 50-ohm coaxial transmission line application. It has a precision-built dual-cylinder type air coupler which gives accurate measurements up into the 150 mc range, says Seco.

Ranges of application are 0 to 10 watts, 0 to 100 watts, and 0 to 1000 watts. A direct reading dial scale is calibrated from 0.5 to 10 watts. An efficiency scale is graduated in per cent and also marked with a "Good-Poor" scale. Accuracy of the unit is ±5 per cent at full scale.

No. 369 on Reader Service Card

OPTICAL COMPARATOR for in-process QC

An optical comparator is now available which permits decentralization of quality control and inspection to numerous points of manufacture. Built by **Micro Vu, Dept. S/A, North Hollywood, Calif.,** this portable unit provides 20 power magnification for inspection of components ranging from microminiature parts to 3-inch AN fittings.

The unit needs less than three sq ft of bench area and weighs about 20 lb. It features a 20X achromatic lens and an eight-inch screen for viewing.

No. 370 on Reader Service Card

TEST CHAMBER with continuous control

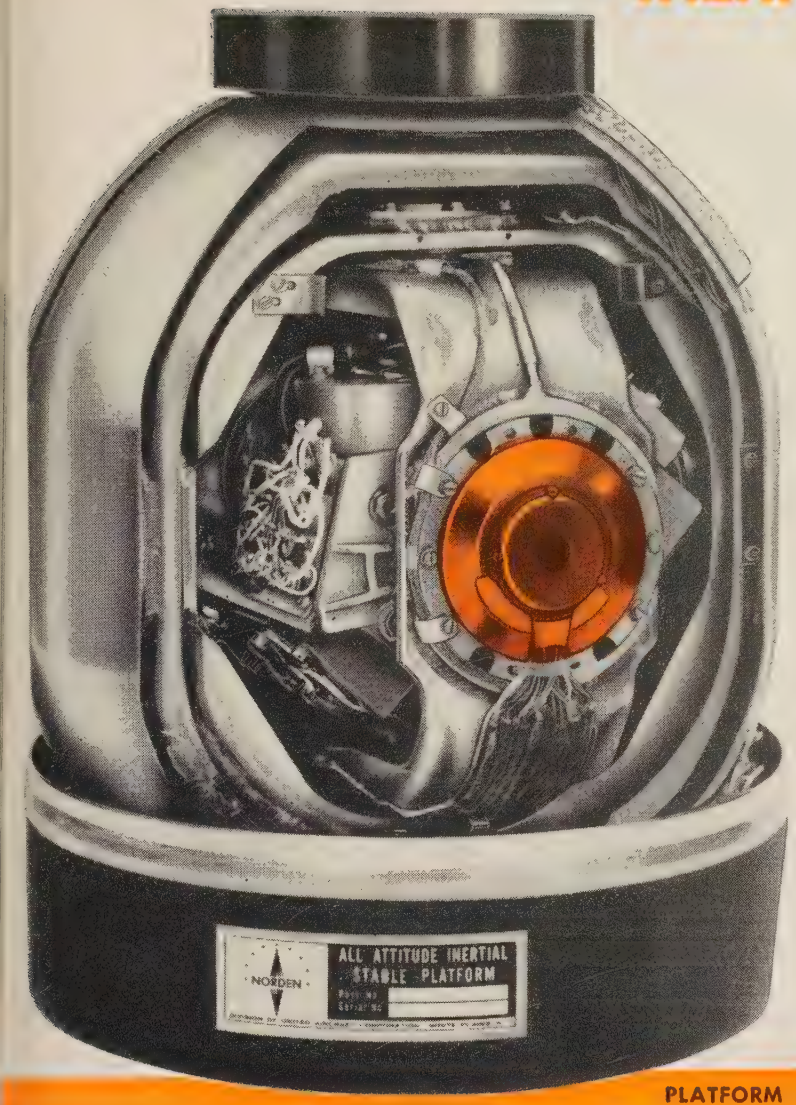
A continuously controllable temperature range from 100 to 200 deg C for environmental temperature testing is now possible with a portable test chamber manufactured by **Giannini Controls Corp., Dept. S/A, 1600 S. Mountain Ave., Duarte, Calif.**

Combining the best features of mechanical and dry-ice refrigeration, this model 3040640 uses bottled liquid CO_2 to achieve super-speed cooling with precise control. A single dial provides complete control of internal temperature. A direct reading thermometer provides visual monitoring.

No. 371 on Reader Service Card

No. 199 on Reader Service Card

INLAND d-c torque motors save critical weight in guidance systems



Norden Miniature All-Attitude Inertial Platform uses four Inland torque motors, one for each gimbal axis.

Norden specifies these Inland d-c torque motors because of their compact pancake shape, low-power input and direct torquing. In addition to providing the obvious weight and space reduction, Inland's direct drive positioning eliminates gear train problems such as backlash.

Norden engineers say, "The linearity of the Inland torquers is excellent over a wide range so that precession rates may be accurately established. The torquer fixed field is carefully stabilized so that the torquer gradients will be constant over long periods of time."

Inland d-c pancake torque motors with high torque-to-inertia ratios and linearity of output provide all the advantages of direct gearless servo positioning in a complete line over the full range of 0.1 to 3,000 pound-feet.

PLATFORM SHOWN ½ SIZE

COMPARE THESE TYPICAL INLAND TORQUER RATINGS

	T-1321-A	T-2136-A	T-2108-B
Peak torque, oz. in.	20.0	35.0	60.0
Volts at peak torque, stalled at 250°C.	48.0	26.0	25.6
Amps at peak torque	1.21	1.6	1.24
Total friction, oz. in.	0.5	0.8	1.5
Rotor Inertia, oz. in sec^2	.001	.007	.011
Weight, oz.	5.0	9.0	14.0
Dimensions (inches):—O.D.	1.937	2.81	2.81
I.D.	.625	1.00	1.00
Thickness	.50	.63	1.00

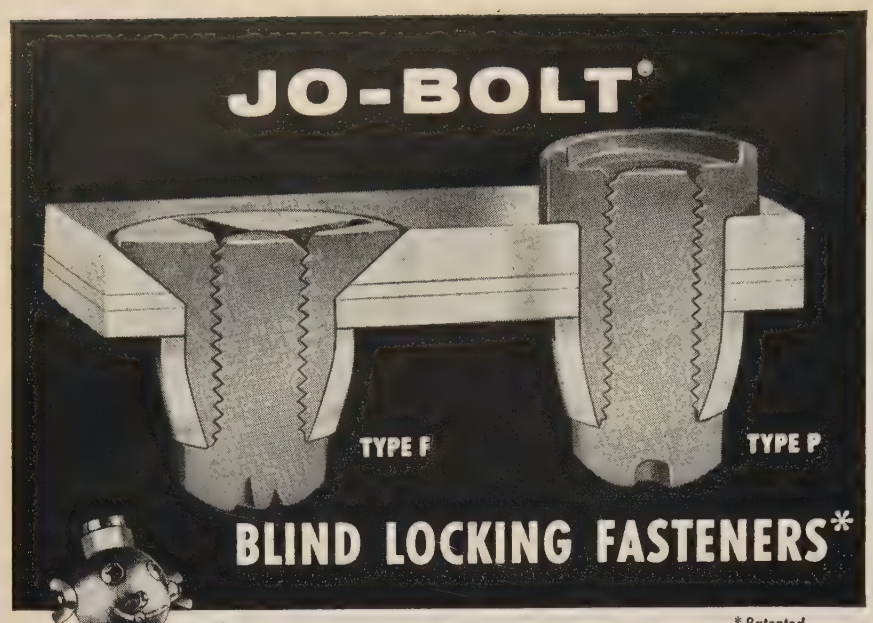
For complete catalog with engineering data, outline drawings and specifications on these and other Inland d-c pancake torquers, write Inland Motor Corporation of Virginia, Northampton, Massachusetts. Dept. 2-10.

INLAND MOTOR CORPORATION OF VIRGINIA

A SUBSIDIARY OF KOLLMORGEN CORPORATION

NORTHAMPTON, MASS.

No. 200 on Reader Service Card

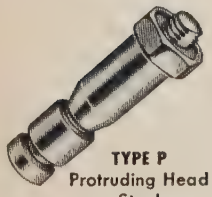


* Patented

DO IT BETTER · DO IT FASTER in missile/aircraft frame assembly

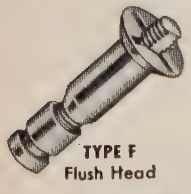
What happens in JO-BOLT Fastener installations can be seen at a glance, in the cross section above. The resulting clamp-up of sheets and structural members is tight and positive, 100% effective.

That's highly important . . . but not even the half of it. First, consider this . . . JO-BOLTS® are high-strength structural fasteners, typically providing: shear strength of 95,000 psi min. in steel types; 85% AN Bolt tensile strength in #10 and ¼" diameters; vibration resistance superior to bolts with lock nuts.



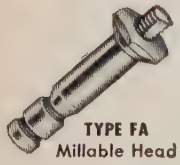
TYPE P
Protruding Head
Steel

Second, JO-BOLT Fasteners are lightweight and compact, allow savings in fastener weights averaging 50% or higher, often permit use of narrower and lighter substructures.



TYPE F
Flush Head

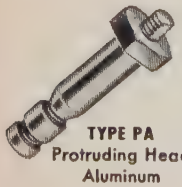
Third, JO-BOLT Fasteners can always be installed by one man from one side of the work . . . eliminating most common access and clearance problems.



TYPE FA
Millable Head

Finally, JO-BOLT Fasteners are foolproof and fast, can be popped into holes prepared and aligned for them, and driven to grip inside of seconds, always resulting in high-quality work, uniform and unmarred, regardless of worker skill.

They are so good, in fact, at fastening better and faster that they've been preferred and specified in practically all high-performance aircraft ever since introduction.



TYPE PA
Protruding Head
Aluminum

Write for illustrated booklet J 59. It lists specifications for all types, tells about A 286 Hi-Temp and other special JO-BOLT Fasteners.

National Screw Products

THE NATIONAL SCREW & MFG. COMPANY
CLEVELAND 4, OHIO
California Division, Los Angeles 22

No. 201 on Reader Service Card

TEST STANDS for gas turbine pumps

A series of test stands for gas turbine governors and fuel pumps is manufactured by **Marine Pumps, Div., Diesel Control Corp., 226 N. Marine Ave., Wilmington, Calif.**

The manufacturer states that the Model U-10000 GT test stands provide laboratory-accurate data on discharge capacity, starting pressure, minimum flow, governor internal leakage, operation of relief valves, idle and high speed control lever settings, and acceleration range.

No. 372 on Reader Service Card

DATA FILE

FACILITY—A brochure outlining environmental test facilities and equipment capabilities is available from **Singer-Bridgeport, Dept. S/A, 915 Pembroke St., Bridgeport, Conn.** The brochure lists equipment and military specifications that are met in testing.

No. 373 on Reader Service Card

TRANSDUCER—A miniature airborne pressure transducer has been designed for measurement of fluid and gas pressures by **Taber Instrument Corp., Dept. S/A, 107 Goundry St., North Tonawanda, N.Y.** Complete specifications, mounting data, sensitivity modification, prices, and ordering information for this Model 183 transducer are given in Bulletin P-61183.

No. 374 on Reader Service Card

MATERIALS TESTING—An illustrated bulletin from **Instron Engineering Corp., Dept. S/A, 2500 Washington St., Canton, Mass.**, presents the Instron capillary rheometer, a high shear instrument for the study of flow behavior of polymer melts and other non-Newtonian fluids at controlled rates and temperatures. A diagram and specifications are given.

No. 375 on Reader Service Card

TURNTABLE — Rate turntables for checking performance of gyros are discussed in a brochure from **Dunn Engineering Corp., Dept. S/A, 225 O'Brien Highway, Cambridge, Mass.** The brochure also includes specifications on tilt stands.

No. 376 on Reader Service Card

This mark tells you
a product is made of
modern, dependable Steel.

Four Skybolt air-to-ground missiles ready for action under the wings of the Air Force B-52 bomber.

Strong steel skin for the Skybolt

An Air Force B-52 bomber will be able to hide in the sky and launch four Douglas Skybolt nuclear missiles at targets 1,000 miles away when this air-launched ballistic missile becomes operational! The Skybolt, presently under development, will give us another strong deterrent against enemy attack.

To obtain this long range, Douglas designers had to trim every ounce of dead weight from the Skybolt without sacrificing strength or performance. They used an ultra-high-strength steel sandwich-rolled between two other steel plates to obtain highly uniform gage and extremely smooth surface. The result—a steel motor case of great reliability. Sandwich-rolled sheets are also commercially available for other industrial applications.

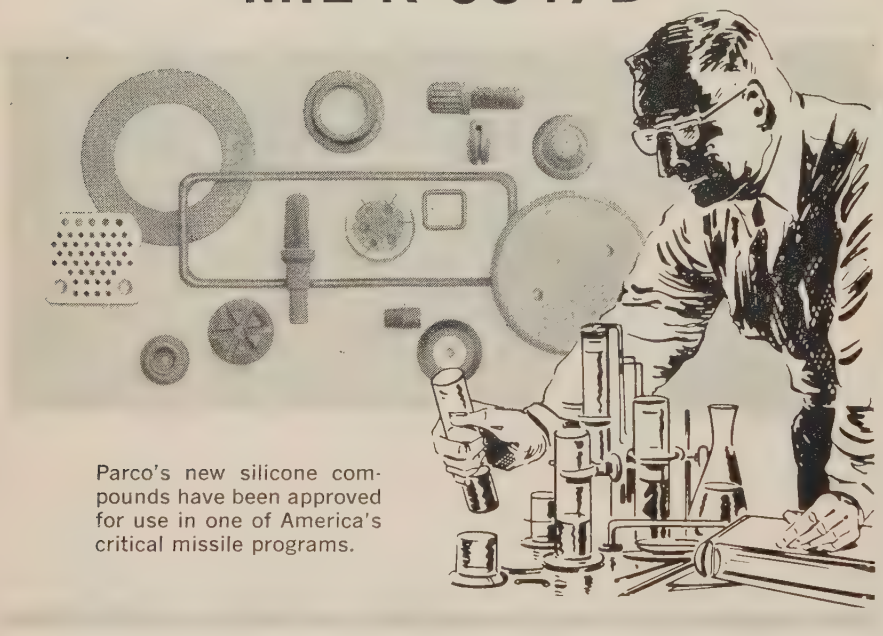
The search for stronger, lighter-weight components has led to general use of ultra-high-strength alloy steels for vital parts of rockets, missiles and aircraft. United States Steel has been a pioneer in their development. All USS Aircraft Quality Steels are accurately controlled during production to meet military specifications, and to assure uniform cleanliness and maximum responsiveness to heat treatment. Our metallurgists are ready at all times to help you make the best selections. For more information, write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa. USS is a registered trademark.

United States Steel Corporation · American Steel and Wire Division · Columbia-Geneva Steel Division · National Tube Division · Tennessee Coal and Iron Division · United States Steel Supply Division · United States Steel Export Company

United States Steel USS

No. 202 on Reader Service Card

Now you can save 300% in inventory with the NEW PARCO SILICONE COMPOUNDS CONFORMING TO MIL-R-5847D



Parco's new silicone compounds have been approved for use in one of America's critical missile programs.

PARCO engineers and chemists have developed a new series of compounds which eliminate ordering confusion.

Specification MIL-R-5847D calls for 5 classes with 24 subordinate grade compounds. Parco engineers, recognizing the need for standardization, developed special compounds which permit each of the 5 class compounds to fulfill 21 of the subordinate grade compound requirements. The 300% reduction in customer-stocked inventory as well as quantity discount cash savings has resulted in an overall increase in stocking, ordering and servicing efficiency.

PRESSURIZED AND DUST CONTROLLED ENVIRONMENT assures complete conformity to specifications no matter how close the tolerance... or demanding the requirement.

PARCO ENGINEERS AND DESIGN LIBRARY ... provide a unique source of engineering knowledge for problem areas you may be investigating. Check with Parco first! Parco may have the solution.

Send for your latest Parco Slide Rule featuring groove dimension tables and conversions for AN and MS numbers.

PLASTIC AND RUBBER PRODUCTS COMPANY
2100 Hyde Park Blvd., Los Angeles 47, California • AX 5-4331

No. 203 on Reader Service Card

Testing and Support

TESTING — A 70-page, photo-illustrated brochure on electrical/electronic test facilities is offered by **Wyle Laboratories, Dept. S/A, El Segundo, Calif.** Brochure No. 1015, describes comprehensive facilities for functional-environmental testing of electrical, electronic, electromechanical, and instrumentation components and systems.

No. 377 on Reader Service Card

CRYOGENIC INSTRUMENTS—An illustrated data file from **Cryogenics, Inc., Dept. S/A, Stafford, Va.,** describes the company's activities in the field of cryogenic instrumentation. It contains information on equipment for accurate measurement of such parameters as temperatures, pressure, flow, and liquid level, and gives specifications for thermocouples, liquid level detectors, and vapor pressure thermometers.

No. 378 on Reader Service Card

TESTING MACHINE—Bulletin RF-2-61 discusses hydraulically actuated fatigue testing machines and is available from **Riehle Testing Machine Div., American Machine and Metals, Inc., Dept. S/A, East Moline, Ill.** The 12-page bulletin illustrates and describes the machines and an optional programmer which automatically varies load control points and frequency, and also contains flow control charts and specification tables.

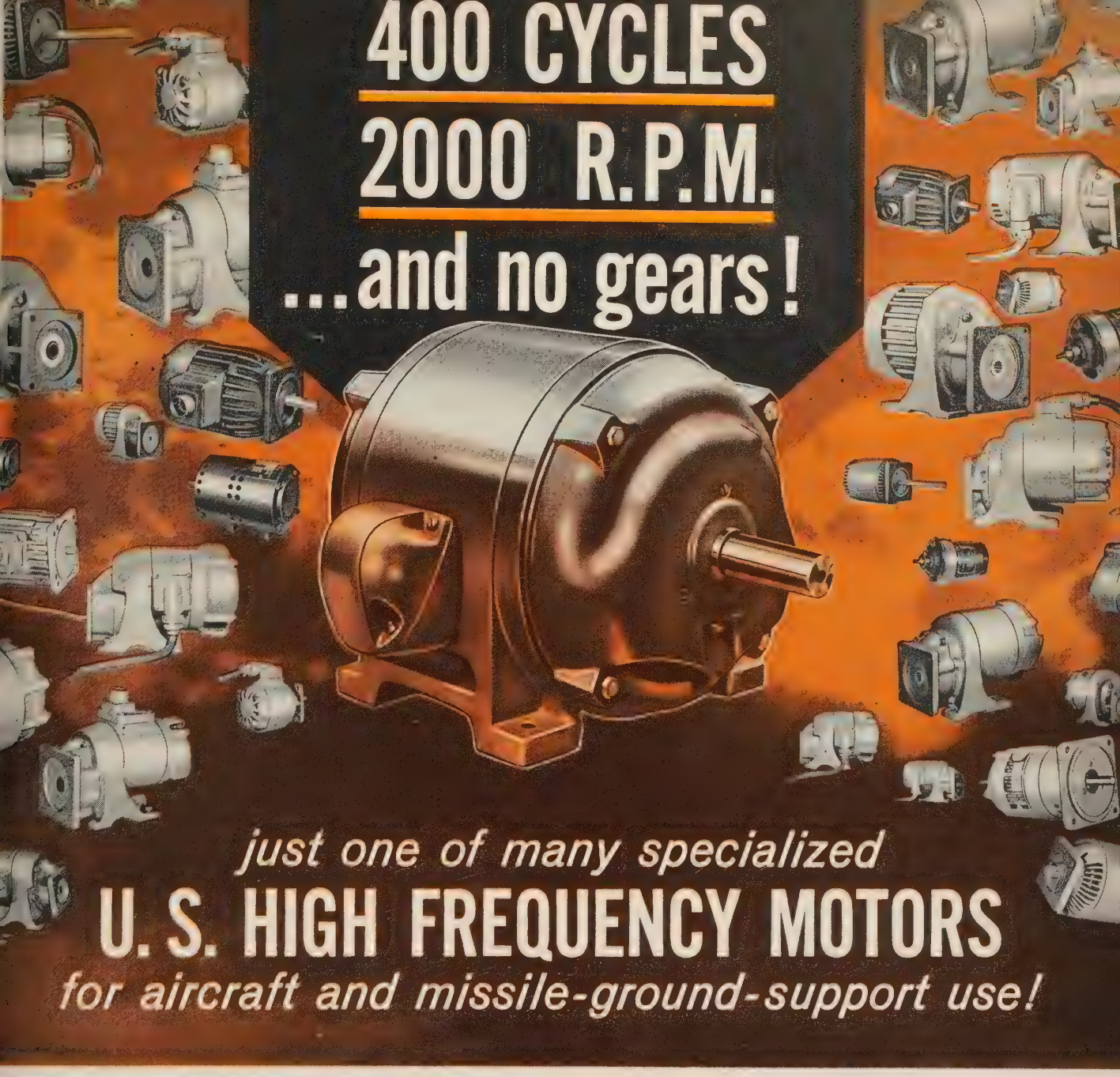
No. 379 on Reader Service Card

TRANSDUCERS—A new series of differential transformer and variable reluctance pressure transducers are described in information available from **Gulton Industries, Inc., Dept. S/A, 212 Durham Ave., Metuchen, N.J.** Both units are reported available with either of two diaphragms for each of seven pressure ranges from 0-15 to 0-500 psig.

No. 380 on Reader Service Card

CAPABILITIES—A 16-page brochure from **Federal Electric Corp., Service Associate of International Telephone and Telegraph Corp., Dept. S/A, Paramus Industrial Park, Paramus, N.J.,** describes the company's contract services for military contractors and the armed forces. It reviews FEC capabilities in operation support planning, maintenance engineering, systems evaluation, and other support disciplines.

No. 381 on Reader Service Card



Now, without gears, a 400 cycle motor producing a slow speed of only 2000 rpm! Heavier, yes—than gearmotors of equal rating—but in ground-support equipment its *longer life, lower lubricant requirements,* and *greater shock-load capacity* provide important advantages.

U. S. Motors makes many other 400 cycle motors, both geared and non-geared, to specifications. Years of solving aircraft and ground-support motor problems have amassed for U.S. invaluable files of basic designs, plus facilities to produce a multitude of adaptable components. Letting U.S. design the particular motor you need can save precious developmental time. U.S. experience assures supreme motor reliability...the most important requirement in aircraft and missile-ground-support electrical motors! Available in Ratings 1/20 to 50 H.P. Let U.S. quote on your motor specifications.

U.S. ELECTRICAL MOTORS INC.

LOS ANGELES 54 (P O BOX 2058) CALIFORNIA – OR MILFORD, CONN.

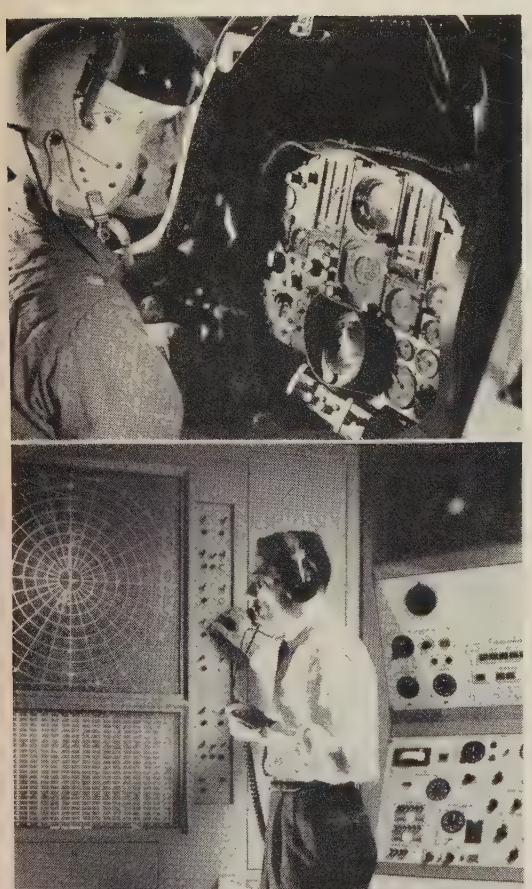
FREE TECHNICAL BROCHURE... for full information send for U.S. Aircraft Motor Bulletin No. F-1950

No. 204 on Reader Service Card

DESIGN DEVELOPMENTS

For more details on the equipment, processes, and facilities described in this section, write in item

F-105D SIMULATOR SETS COMPLEXITY RECORD



The first electronic flight and tactics simulator for the Air Force's F-105D fighter-bomber has been delivered to the Tactical Air Command by ACF Electronics Div., ACF Industries, Inc., Riverdale, Md. According to ACF, this is the most comprehensive flight simulator ever built, in keeping with the complexity of the supersonic F-105D itself, which has been called "the most powerful one-man airplane in the world." The F-105D pilot must also be a navigator, gunner, and bombardier, and all these functions as well as others are simulated electronically in the trainer. The ACF system can be used for both familiarization training and operational mission training (by simulating the aircraft's NASARR (*N*orth *A*merican *s*earch *a*nd *r*anging *r*adar.

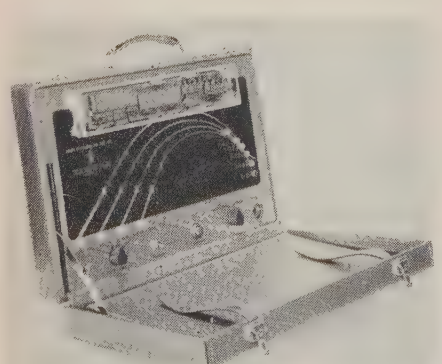
Besides experiencing all flight characteristics of the aircraft while training in the simulator, the pilot, by using the radar portion of the simulator, can actually "pre-fly" courses all over the world without ever leaving his base station. Three-dimensional terrain maps, a pin-point light source, and TV-type cameras are the essential components of the system, which reproduces, on the trainer's radar scope, the exact pictures a pilot would see on actual missions.

For radar simulation, a gantry mechanism is used that has two cameras moving freely between two vertical maps that are in perfect registration, "reading" altitude information from one map and terrain information from the other. The gantry moves according to the movements of the "aircraft" as introduced by the pilot or the instructor. The light source represents the area of actual radar antenna radiation and illuminates the area on the terrain map over which the simulator is "flying." The "radar pickup" from the maps is relayed by the cameras to computers for further relay as a single picture on the aircraft's radar scope. Should the pilot err and "fly" into a terrain feature, the light source would touch the map, causing a simulated crash.

Other major features of the simulator are:

- A radio target and facility system provides the pilot with radio communications and navigation information. The pilot has two radio stations available to him at all times. These are selected in

Digital Arming Programer-Timer is Compact



A highly compact arming programer-timer using digital techniques has been announced by Diamond Ordnance Fuze Labs, which designed the system, and Cleveland Metal Specialties Co., Cleveland 14, Ohio, which built and packaged it.

The unit is constructed of modules with a density of 500,000 parts per cu ft, and fits into a canister no larger than a small soup can. A "spread out" demonstration version has also been built in an attache case so that its functions can be visualized.

The demonstration unit has a switch panel, to simulate four different flight times, and timing sequence lights. The electronic packages of the clock, timer, readout and switching sections have also been mounted for easy viewing.

In actual missile operation, the programer-timer, essentially a digital electronic-clock computer, operates according to a program set in before launch. **63**

Electronics

Reader Service Card

any combination from six preprogramed stations of three types—Tacan, ILS, UHF-ADF. A keyer for each of the six stations electronically develops, times, and keys the call letters. (It uses beam-switching tubes and has no moving parts.)

• In a very-high-fidelity sound simulation system, frequency and volume are mixed and modified by multiple variable-frequency oscillators to reproduce engine noise as it occurs when the "throttle" is open.

• An "oxygen supply" that provides blown and filtered fresh air.

• A system for simulating external stimuli like the jounce and screech of the tires as they hit the runway.

• A "folded optical slide projection system" using eight magazine slide projectors that operate independently or simultaneously to show where the pilot is in relation to the terrain and altitude requirements of his training situation. Projections are mixed and folded on an angular screen and reflected on two translucent boards—one for altitude and the other for geographic information. Reference map slides change automatically as the pilot "flies off the slide" and expand in scale as he "nears his target." In addition, plotting slides are used; their opaque surfaces are scribed with a "flight record."

• Special ACF computer equipment that runs 24 hours a day with minimum maintenance. "Plug-in-pull-out" amplifiers and hinged, easily accessible panels simplify maintenance.

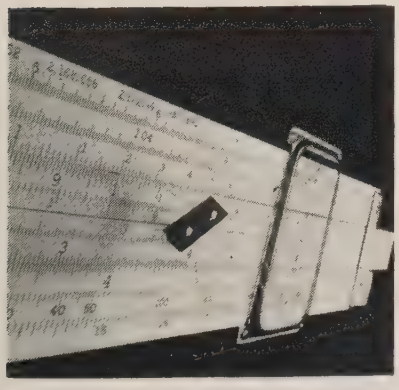
• A trouble alarm system and an automatic test and checkout system to insure operation at peak efficiency and minimize down-time. The first system visually indicates malfunctions in the computer system; the second system completely tests the flight portions of the simulator, providing both a digital read-out and a machine printout giving information on the test in progress.

The entire system consists of a cockpit, an instructor-operator console, a map room, and two lines of back-to-back computers and related equipment. Three men "make it go" in a typical training situation: the pilot, the instructor, and the operator (who assists the instructor).

The complete system contains some 390,000 parts, weighs 16 tons, takes up 35 sq ft, contains 150 miles of wiring, and provides the instructor and operator with 667 controls and indicators to watch what the pilot is doing and induce malfunctions that the pilot must correct.

The cost per system is $1,300,000. **66**

Silicon Disk Is Molecular Slide Rule

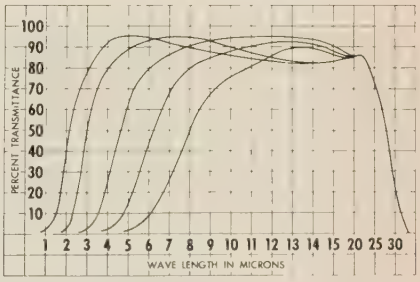


Scientists at the research lab of Westinghouse Electric Corp., Box 2278, Pittsburgh 30, Pa., have demonstrated a electronic device that multiplies and divides in a manner similar to that of mechanical slide rules. The new device has no conventional electronic components or circuitry. The latest of Westinghouse's molecular-electronics subsystems, or functional electronic blocks, is a small disk of silicon—about the size of the head of a thumbtack.

KODAK FAR INFRARED FILTERS

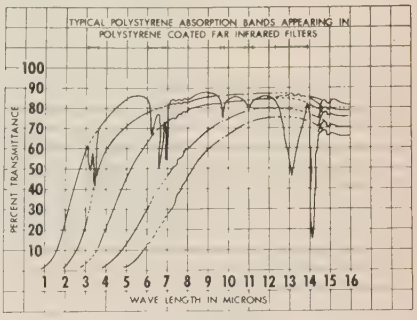
to set a short-wavelength boundary for the infrared

Kodak makes blocking filters of silver chloride with a silver sulfide surface layer that removes radiation up to a selectable wavelength. By control of the nature of this layer, we place the boundary (defined as 3% transmittance) anywhere between 1μ and 5μ, as follows:



KODAK FAR INFRARED FILTERS SERIES 200
(No protective coating)

We can also supply them with protective coating. This is recommended if you can tolerate the absorption bands:



SERIES 200S
(Polystyrene protective coating)

These Kodak Far Infrared Filters are often teamed up with optical interference filters that isolate a given infrared band but need help to keep out the shorter wavelengths.

For details and prices, write:

EASTMAN KODAK COMPANY
Apparatus and Optical Division
Rochester 4, N.Y.

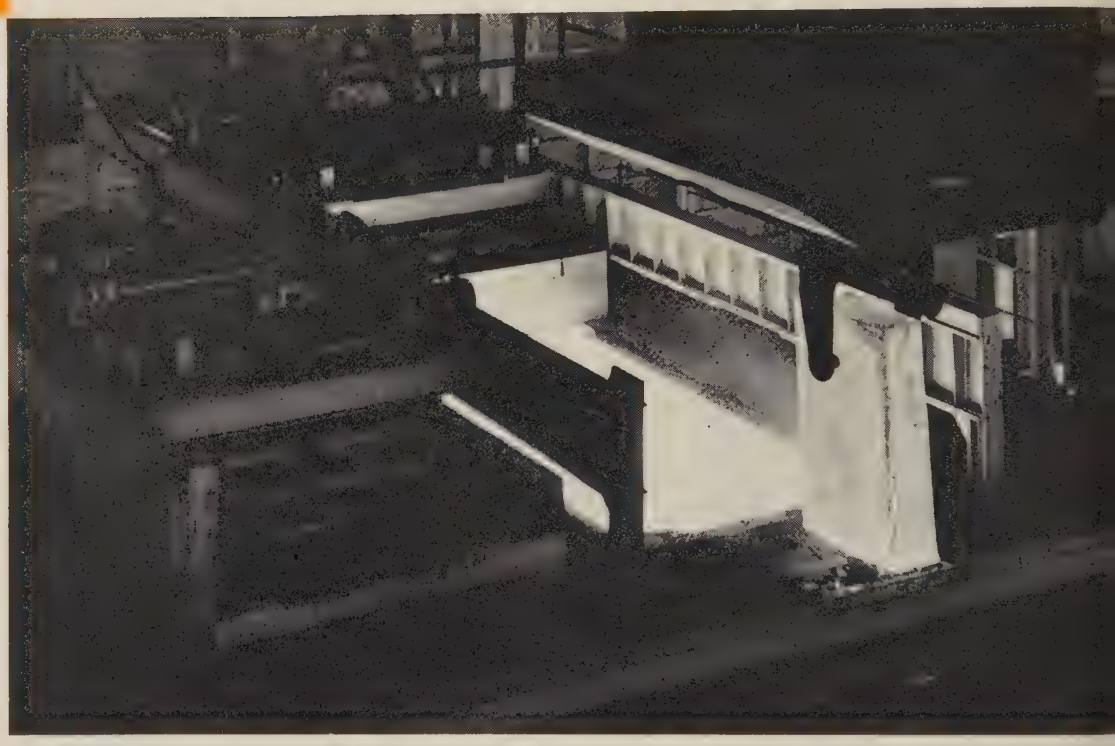
Kodak TRADE MARK

No. 205 on Reader Service Card

TOO LATE NOW FOR TRIAL AND ERROR!

Play Safe with the PROVED Quality of

Acme-Newport Steel



Prime and subcontractors long ago found important ingredients of aircraft quality steel to be the modern facilities, skilled craftsmen, quality control and 77 years' experience of this basic steel producer. In these critical times they more than ever insist on this *known* quality, and specify Acme-Newport for component parts in missiles, rockets and ground support equipment. Acme-Newport is a specialist in this field, deservedly famous for strict adherence to specifications for low alloy and carbon grades in plate, sheet and strip. If that's what *you* demand, call Acme-Newport!

Acme-Newport Steel COMPANY

NEWPORT, KENTUCKY

A SUBSIDIARY OF ACME STEEL COMPANY

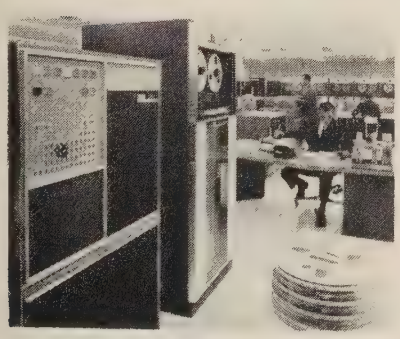
Steel

No. 206 on Reader Service

An electric current fed into a junction produces a voltage across the junction proportional to the logarithm of the current. An input of two currents into two junctions produces a voltage that represents the currents' logarithmic sum. The anti-logarithm which is measured at the output of the functional block is the product of the multiplication of the current.

Just as in a slide rule, division is the opposite process. Two currents are fed into the multiplier-divider so that their logarithms subtract rather than add. Used as a multiplier or divider, the device has an input range of 10:1, and an output range of 100:1 and is accurate within five per cent. **68**

Tape Unit Ties Together Far-Flung Computers



A magnetic tape unit for the high-speed transmission of digital data between computer installations via telephone cable and a Bell System microwave radio network has been announced by International Business Machines Corp., Data Processing Div., White Plains, N. Y. With the 1945 IBM, computers at various locations can be interconnected so that they can be run as if they were in the same room.

The 1945 IBM is a solid-state, self-powered unit for the high-speed transfer of digital data over broad-band communications systems. Basically it is a remote tape reading control unit. The computer controls the remote tape unit through tones transmitted over a voice frequency channel. On receipt of a "go" signal, generated in the 1945 by a read-select command from the computer, the transmit tape is set in motion.

Information recorded on the tape is sensed by dual-level sensing circuits and transferred as seven parallel bits to the broad-band transmission channels. The data rate for the standard 1945 is 15,000, 22,000, or 41,700 characters per second (depending on tape density and speed). With added circuitry, the 1945 will transmit at a maximum rate of 62,500 characters per second.

The transmit and receive functions of the 1945 are independent, providing full duplex-mode operation. The computer at the sending end is not used for the data transmission operation and can therefore receive data from the other end or perform its normal functions. **70**

STATIC CONVERTER has high power output

A line of ultra-precision frequency and pulse rate to voltage converters, designated high power Magacyclers, is now available from **Pioneer Magnetics, Inc., Dept. S/A, 850 Pico Blvd., Santa Monica, Calif.**

Standard units cover ranges from 5 cps to 12 kc (100 kc available on request). Built-in attenuators allow a 4 to 1 adjustment of full scale. Accuracy is reported to be ±0.5 percent, with less than 100 ppm/deg C temperature sensitivity. Full scale output range is to 10 volts with load variations of 1000 ohms to 1 megohm.

No. 382 on Reader Service Card

CATHODE RAY TUBES give uniform voltages

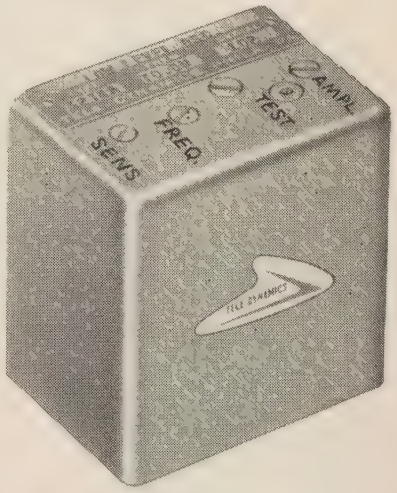
Spiral accelerator cathode ray tubes using an internal resistance coating to provide uniform increases in accelerating voltages are being marketed by **Sylvania Electric Products, Inc., Dept. S/A, 730 Third Ave., New York 17, N. Y.** The aluminized tubes provide high deflection sensitivity and accuracy, as well as electrostatic deflection and focus.

Two series, 5BGP and 5BHP, of 5-in. tubes have been designed. They are available in a variety of phosphors, in addition to the standard P2.

No. 383 on Reader Service Card

TELEMETRY BY TELE-DYNAMICS

NEW Low Level Subcarrier Oscillator



The Type 1274A Low Level Subcarrier Oscillator is an outstanding member of Tele-Dynamic's new line of transistorized telemetry components for today's aerospace applications.

Designed to operate at unlimited altitudes, the 1274A can be activated by a ± 5 millivolt level differential signal. The input impedance is greater than 90 K ohms. It is extremely stable, has true differential floating input, and inherent deviation limiting which prevents over-deviation of greater than ± 22% from center frequency. Common mode rejection is 110 db min. for a 10 volt peak to peak AC signal up to 2100 cycles. Silicon transistors allow operation over broad temperature ranges and latest packaging techniques reduce the volume of the 1274A to only 4.5 cu. in. and its weight to approximately 4 ounces.

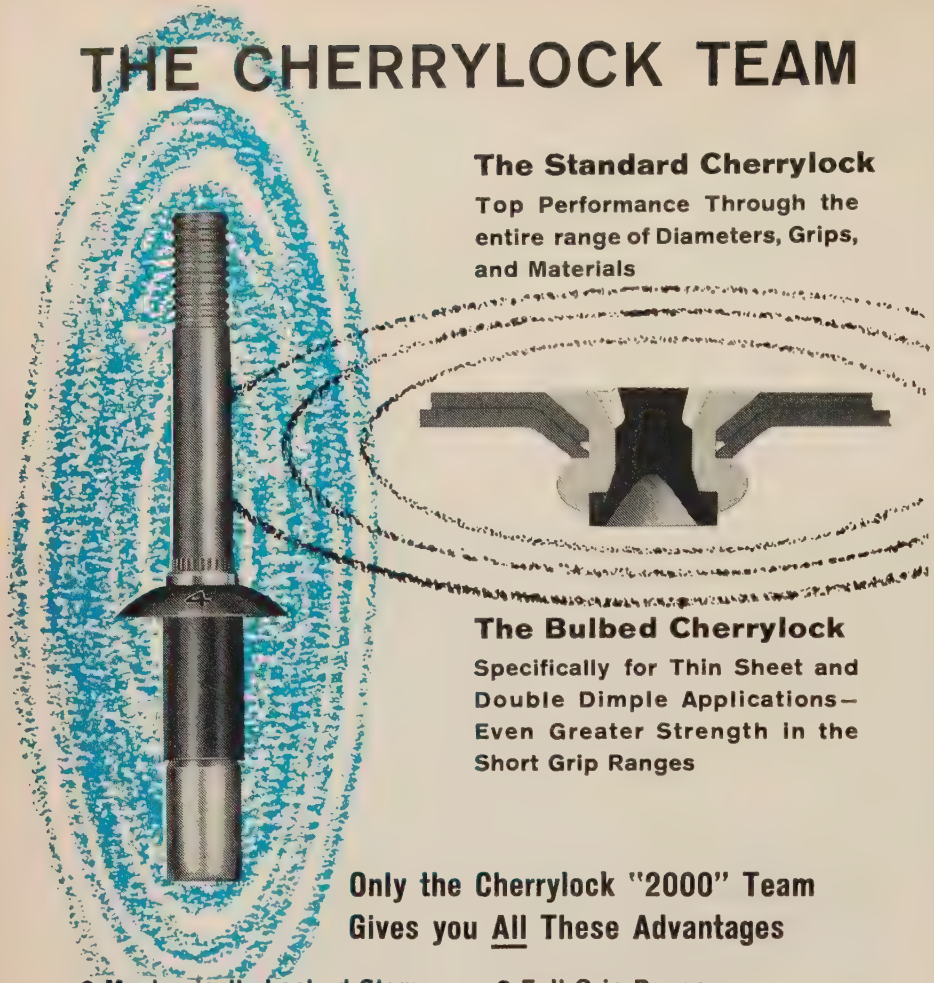
For detailed technical bulletins, call the American Bosch Arma marketing offices in Washington, Dayton or Los Angeles. Or write or call Tele-Dynamics Division, American Bosch Arma Corporation, 5000 Parkside Avenue, Philadelphia 31, Pa. Telephone: TRinity 8-3000.

8410

TELE-DYNAMICS
DIVISION
AMERICAN BOSCH ARMA CORPORATION
5000 Parkside Ave., Philadelphia 31, Pa.

No. 209 on Reader Service Card

THE CHERRYLOCK TEAM



The Standard Cherrylock

Top Performance Through the entire range of Diameters, Grips, and Materials

The Bulbed Cherrylock

Specifically for Thin Sheet and Double Dimple Applications—Even Greater Strength in the Short Grip Ranges

Only the Cherrylock "2000" Team Gives you All These Advantages

- Mechanically Locked Stem
- Flush Fracture (No Stem Trimming)
- Positive Clamp-up
- Full Grip Range
- Complete Hole Fill
- Positive Visual Inspection (Grip Marked on Head)

A-286 Stainless Steel—Monel—Aluminum

The Cherrylock* "2000" series team offers the finest, most adaptable aircraft rivets yet developed. Maximum joint strength and reliability are obtained by using the Standard Cherrylock and the Bulbed Cherrylock to cover the entire range of applications. The Bulbed Cherrylock for short grips and double dimple, the Standard Cherrylock in the longer grips. Both types are installed with the same H-610 series pulling head, using existing Cherry guns.

Higher joint strength allowables, close blind side clearance, and the widest grip range available—only with the Cherrylock Team—result in better fastening at lower cost. The Cherrylock Team provides the strongest mechanical lock—flush fracture rivet available. Positive visual inspection after installation—with grip length marked on the rivet head—is offered only by the Cherrylock Team.

* * *

For technical data on the Cherrylock Team of rivets, write Cherry Rivet Division, Townsend Company, Box **2157-P,** Santa Ana, Calif.

*Patent No. 2931532

A textron COMPANY

CHERRY RIVET DIVISION

SANTA ANA, CALIFORNIA

Townsend Company

ESTABLISHED 1816 • BEAVER FALLS, PA.

In Canada: *Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario*

DIODES operate to 500 deg C

Three high temperature diodes that operate in sustained ambient temperatures up to 500 deg C have been announced by **General Electric Co., Dept. S/A, Schenectady 5, N. Y.** Current ratings range from 0.15 to 10 amps for these tubes.

The 10-amp tube is a medium size rectifier with a peak inverse anode voltage of 200 volts. The filament operates at 2.5 volts and 85 watts. Peak cathode current is 125 amps. The 2-amp model has a peak inverse anode voltage of 750 volts. Filament rating is 2.5 volts, 20 watts power. Peak cathode current rating is 25 amps. The 0.15-amp rectifier has a peak inverse anode voltage of 1000 volts. Its filament operates at 1 volt, with a power of 10 watts. Peak cathode current rating is 2 amps.

No. 384 on Reader Service Card

SIGNAL SIMULATOR for PCM telemetry

A signal simulator which provides PCM signals for checkout, calibration, or evaluation of PCM telemetry equipment has been desgned by **Electro-Mechanical Research, Inc., Dept. S/A, Sarasota, Fla.** This model 208A can set bit rates of 50 to 200,000 bits per second, in the range of 1 to 256 words, with word lengths from 1 to 16 bits.

Both serial and parallel outputs are provided. The unit can simulate such errors as word synchronization, frequency modulation or drift, adding of noise, and bit dropout. The unit is completely transistorized and can be mounted in a standard 19-in. rack. A power supply is included.

No. 385 on Reader Service Card

VARIABLE DELAY LINE has unrestricted settings

Previous mechanical restrictions on setting sliding taps on variable delay lines have been overcome by **Allen Avionics, Inc., Dept. S/A, 255 E. 2 St., Mineola, N. Y.,** in their model VLR 15 variable delay line. In this model, sliders have been designed to pass one another and thus permit unrestricted, individual settings.

The model is 2 x 3 x 8 in., with extended shaft length of 1⅛ in. Each tap has a resolution of 0.025 usec, with a maximum rise time of 0.072 usec for the network. Delay is variable from 0 to 1.5 usec. Attenuation is down to 2 db maximum, and distortion due to spurious response is 1.0 maximum. Hermetically sealed, the unit has passed life tests in excess of 2000 hours, says Allen.

No. 386 on Reader Service Card

No. 208 on Reader Service Card

MINIATURIZED
PRESSURE REGULATORS

Grove Mity-Mite®... light, compact, accurate for reducing, relief and back pressure control. Grove Mity-Mite regulators are materially smaller than conventional regulators of comparable capacities. They are available for pressure reduction, combination reduction and relief, and back pressure services. Mity-Mites utilize the same proven gas dome-loaded principle of Grove Powreactor® Regulators—a design that has set engineering standards for every pressure regulator used in aerospace today! Mity-Mites may be supplied in externally or internally loaded models in dural or 18-8 (type 303) stainless, from ¼" to 1", with inlet pressures to 10,000# psi; outlet pressures to 6,000# psi. For complete engineering data, send for Bulletin #940-H.

GROVE REGULATORS

GROVE VALVE AND REGULATOR COMPANY

a subsidiary of Walworth Oakland and Los Angeles, California

Another Way Grove Sets Regulator Standards for Others to Follow

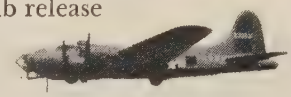
No. 209 on Reader Service Card

AGASTAT® reliability
time/delay/relay

played an important part in these aviation achievements...

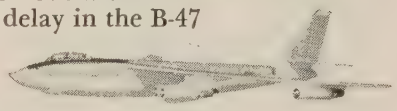
1931 introduction of night airmail from New York to Chicago—birth of AGASTAT principle for airfield landing-light control.

1942 B-17s and B-24s used AGASTAT time/delay/relays for control of the bomb release signal system.



1949 P-80, the first production jet fighter, relied on AGASTATs in the jet ignition system.

1954 hermetically-sealed AGASTATs provided a fixed time delay in the B-47 armament system.



1955 B-52 jet bombers employed AGASTAT time/delay/relays for controlling bomb bay door closure.

1957 Atlas ushered in the ICBM age with AGASTAT time/delay/relays both in the bird and ground control system.

TODAY'S solid-state AGASTAT represents another important step forward in relay technology. This miniature time/delay/relay offers the reliability and accuracy essential for critical missile and computer use. 18-32 vdc; —55 to 125°C. Range .01-sec. to 10-hrs., on pull-in or drop-out. Base size—1 5/16" sq.

ESNA pioneered the electrically-actuated pneumatically-timed relay in 1931, and today offers a full line of time/delay/relays—your guarantee of objective application engineering assistance. Write for information on these high-reliability units, or for a quotation on your specific requirements. Dept. **S4-210**

AGASTAT TIMING INSTRUMENTS
ELASTIC STOP NUT CORPORATION OF AMERICA
ELIZABETH DIVISION • ELIZABETH, NEW JERSEY

IN CANADA: ESNA CANADA, LTD., 12 GOWER ST., TORONTO 16, ONTARIO, CANADA

No. 210 on Reader Service Card

MAGNETIC SYSTEM edits telemetered tape

A magnetic tape editing system has been designed to provide simultaneous editing of two magnetic tapes resulting from telemetry tracking of long-range guided missile tests. The system, developed by **Gulton Industries, Inc., Dept. S/A, 212 Durham Ave., Metuchen, N. J.**, provides automatic searching and correlation of recorded data.

A panel-lit editing decision indicator shows which track is being recorded. Manual or automatic synchronization within 500 microsec is provided for. Inputs are standard IRIG FM/FM channels from tape playback systems. The unit is said to reduce the number of range sites needed, and makes possible the centralizing and speeding of data collection from satellites.

No. 387 on Reader Service Card

BACKWARD DIODES give high conductance

Germanium backward diodes are now in production at **Lansdale Div., Philco Corp., Dept. S/A, Lansdale, Pa.** These diodes provide high forward conductance as a result of the quantum-mechanical tunnel effect which is basic to operation of tunnel diodes.

Important characteristics of this backward diode include: maximum forward voltage at 1 ma—90 mv; maximum peak point current—100 ua; minimum reverse breakdown voltage at 1 ma—480 mv; typical valley capacitance—35 pf; series inductance —1 muh. Designated IN3353, the diodes were designed for high frequency, low level applications.

No. 388 on Reader Service Card

RECTIFIER is silicon-controlled

The TI-40 SCR is a low-cost silicon controlled rectifier for use in consumer devices, as well as industrial controls. Available from **Texas Instruments, Inc., Dept. S/A, P.O. Box 5012, Dallas 22, Tex.**, it has a forward current rating of 3 amps and forward and reverse voltages of 200 volts.

It is expected to find wide usage in light dimmers, electric blenders, and small industrial ovens. The TI-40 is produced entirely by the diffusion process which produces consistent parameters and uniform junction planes through precise control of junction depths.

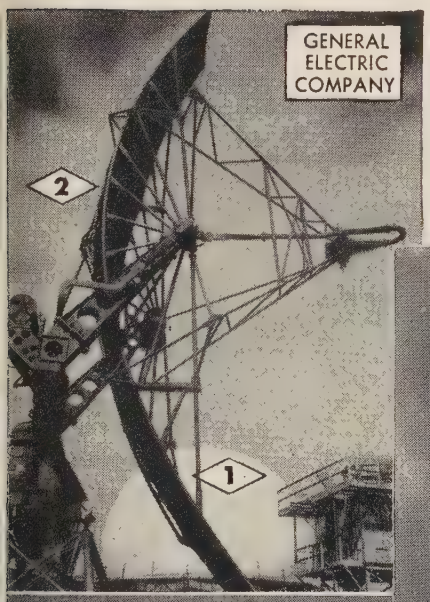
No. 389 on Reader Service Card

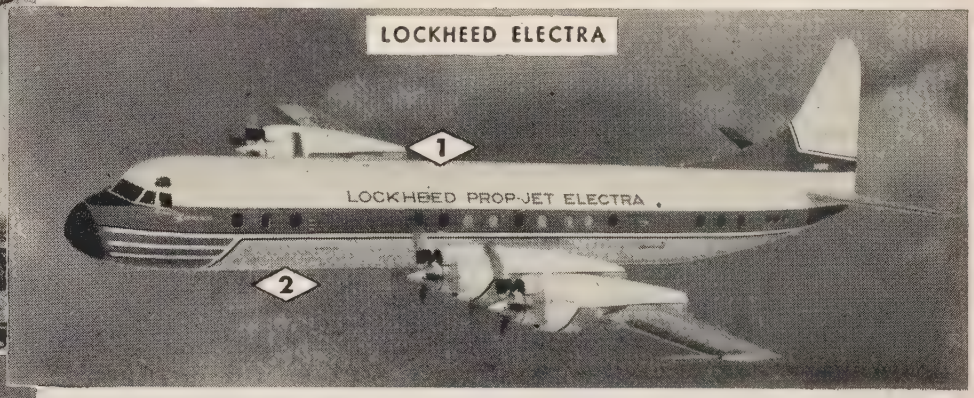
LOOK FOR THE DIAMONDS—SIGN OF FINISHING QUALITY

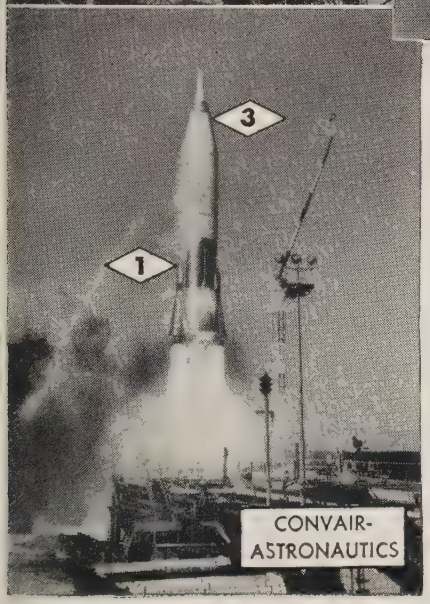
for a superior paint base on light metals you need IRIDITE®

PROCESS ENGINEERED CHROMATE CONVERSION COATINGS

1. Iridite protects against high altitude weather extremes and against corrosion by hydrocarbon fuels, such as gasoline and kerosene.
2. Iridite provides a highly protective non-porous paint base.
3. Iridite protects against corrosive storage conditions.







And, Iridite gives you these additional advantages:

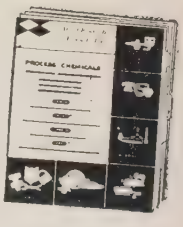
ON ALUMINUM—needs only normal pre-cleaning. Film withstands cold forming or bending. Easily heliarc welded. Unusually low electrical resistance. Clear, yellow or dye-colored finishees.

ON MAGNESIUM—short immersion, room temperature solution, no electrical equipment. Corrosion protection relatively unaffected by high drying temperatures. Applicable to all alloys. Low electrical resistance. Color ranges from light gray to dark brown.

IRIDITE—a specialized line of chromate conversion coatings for non-ferrous metals. Easily applied at room temperatures with short immersion, manually or with automatic equipment. Forms a thin film which becomes an integral part of the metal. Cannot chip, flake or peel; special equipment, exhaust systems or highly trained personnel not required.

Iridite is approved under government and industrial specifications.

For complete information on Iridite, contact your Allied Field Engineer. He's listed under "Plating Supplies" in the yellow pages. Or, write for FREE TECHNICAL DATA FILES.



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Affiliated operations in principal countries

No. 211 on Reader Service Card

CW RECEIVER uses video chopping

A small, self-contained X-band CW crystal video receiver which uses video chopping has been developed by **AEL, Inc., Dept. S/A, 121 N. 7 St., Philadelphia, Penna.** Designated model R115, it is designed for direct connection to an antenna. By means of its built-in waveguide crystal mount, video chopper, and chopper driver, it provides a DC output proportional to the X-band signal input.

Nominal sensitivity of the unit is –45 dbm. Units can also be obtained for narrow or broadband applications with tangential sensitivities over –60 dbm.

No. 390 on Reader Service Card

SOLID STATE RECEIVER has ten channels

A solid state, 10-channel receiver for unmanned aircraft has been announced by **Babcock Electronics Corp., Dept. S/A, Costa Mesa, Calif.** The unit has a carrier-operated relay to assure reliable performance under adverse signal-to-noise conditions.

This BCR-47A receiver is crystal controlled for FM operation on the 406 to 549.5 mc range. It provides 10 control channels operating on standard IRIG audio tones. Up to six channels may be energized simultaneously with a deviation of ±20 kc per channel, resulting in a total bandwidth spread of ±120 kc for the six channels. Each channel controls a 2-amp SPST relay for remote control instructions.

No. 391 on Reader Service Card

OSCILLATOR has plug-in option

A miniature oscillator, designated Model VOG-100-2, is designed to convert d-c voltage amplitude to FM signals for radio or wire distant transmission. The unit is available in standard ROB channels and with a plug-in option.

Designed by **Astronautics Inc., Dept. S/A, Melbourne, Fla.,** the telemeter meets applicable military specifications. Weight does not erceed 7.4 oz. and the size is 1⅞ x 1²⁷⁄₆₄ x 2³⁄₁₆ in. Front panel potentiometers provide control of frequency, sensitivity and output level. A test point allows output voltage measurements.

No. 392 on Reader Service Card

Ku-BAND MAGNETRON for airborne radar

A Ku-band pulse magnetron for airborne radar systems has been announced by **Bomac Laboratories, Dept. S/A, Beverly, Mass.** This BLM-071 model is a fixed-frequency tube, rated 100K w peak power.

Operation is reported possible in relatively high ambient temperatures. Frequency range is 15.9K to 16.1K mc. Input/output terminals may be pressurized to 30 psia. Pulse duration is 0.06 to 1.2 microseconds. This ruggedized tube weighs 8 lb.

No. 393 on Reader Service Card

TELEMETRY FILTERS cover all standard bands

Low pass, bandpass, and high pass telemetry filters in the N series have been introduced by **Key Resistor Corp., Dept. S/A, Gardena, Calif.**

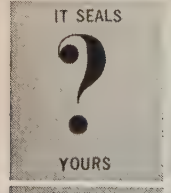
Amplitude of the output signal is held within 1.5 db of input. Insertion is less than 3 db. Input impedance can be from 500 to 50,000 ohms with matching load ranges from 10,000 ohms to infinity. Distortion characteristics are less than 1 per cent.

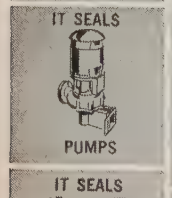
No. 394 on Reader Service Card

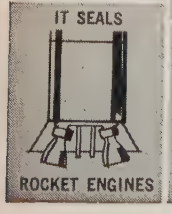
BAR-X® SEALS EVERYTHING

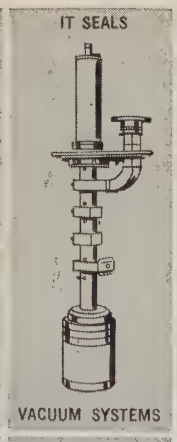
AT TEMPERATURES FROM –400° F TO +1500° F!

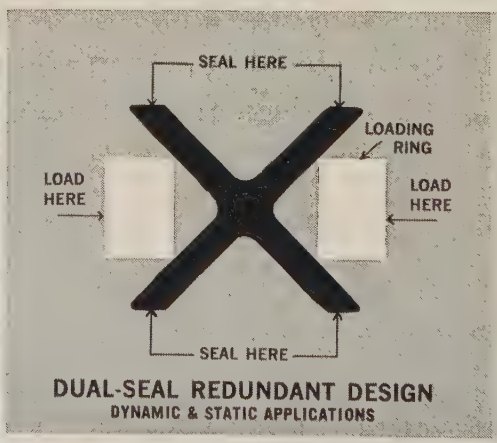
ANY FLUID—GAS—FUELS—WATER—LIQUID METALS—CRYOGENIC FLUIDS—CORROSIVE FLUIDS
ANY SYSTEM—HYDRAULIC—PNEUMATIC—VACUUM—CRYOGENIC—NUCLEAR



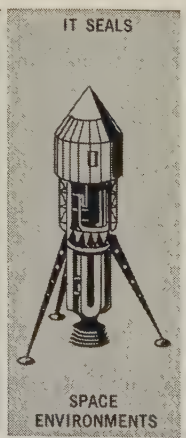


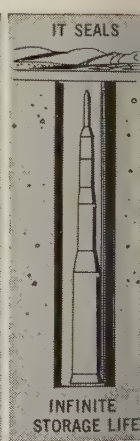






DUAL-SEAL REDUNDANT DESIGN
DYNAMIC & STATIC APPLICATIONS





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UNPRECEDENTED SERVICE LIFE

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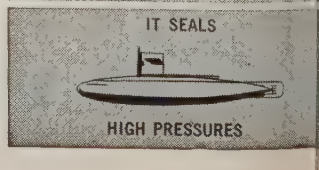

Wiggins

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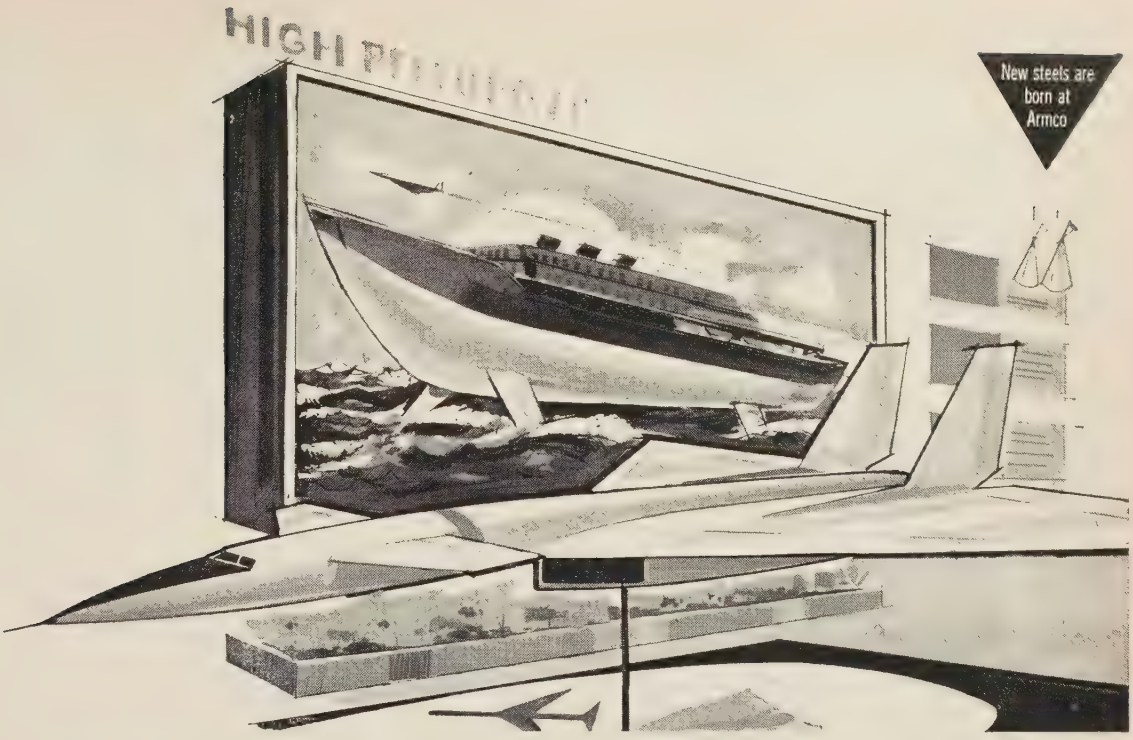


SEE HOW AND WHERE

ARMCO PRECIPITATION-HARDENING STAINLESS STEELS CONTRIBUTE TO NEWEST MISSILES AND AIRCRAFT

Armco exhibit at SAE Missile and Aircraft Engineering Display will feature performance-improving and cost-saving applications of PH 15-7 Mo, 17-7 PH and 17-4 PH stainless steels.

At Booths 74-75 you will see specific examples in which the combination of corrosion resistance, high strength, and producibility has been utilized to improve design and cut production costs. Besides data on in-production parts, helpful information will be available on the use of these special Armco Stainless Steels in many design-stage projects such as the B-70, hydrofoil seacraft, and new missile components.

Stainless Steel

For Strength, Durability and Economy

In addition, Armco engineers, conversant with the specific requirements of missile and aircraft metals, will be on hand. They will be glad to work with you in evaluating the advantages of these space-age Armco Stainless Steels.

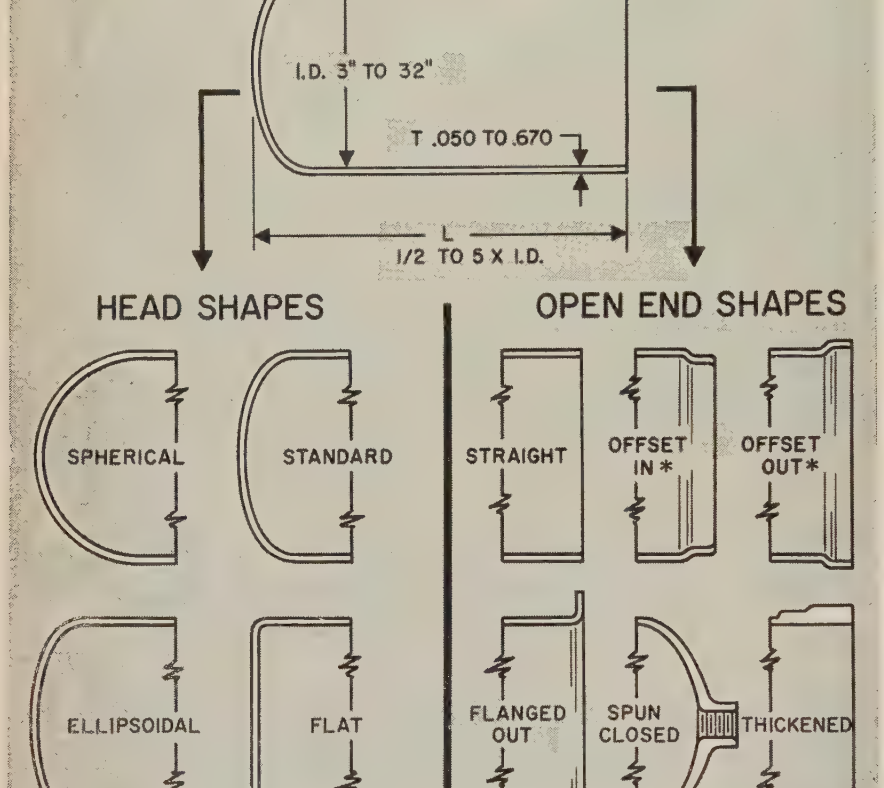
If you attend the SAE Display be sure to visit Booths 74-75. If not, write us for complete information, **Armco Division, Armco Steel Corporation, 3631 Curtis Street, Middletown, Ohio.**

ARMCO

Armco Division

No. 213 on Reader Service Card

Your ideas...our methods...give you reliable components at low cost



The drawings shown here give you a simple description of the way you can use basic Hackney shells to produce a variety of seamless, lightweight, strong, low-cost rocket motor cases, gas generator housings, control actuator pressure vessels and other missile components.

The basic unit is a cold drawn, deep shell which has uniform wall thickness from top to bottom in ranges from .050″ to .670″. I.D.'s vary from 3″ to 32″. The length of the shell may be from ½ to 5 times the diameter—or up to 110″.

Head shapes—spherical, standard, ellipsoidal, flat or special. *Open end shapes* offer variety—straight cut, offset in, offset out, flanged out, flanged in, spun closed or thickened. *Capacities* begin at 1 quart—go as large as 100 gallons. *Working pressures* range from 100 to 6000 psi, depending upon diameter and wall thickness.

For full details of our facilities and our methods of making components, write to the address below.

Pressed Steel Tank Company

Manufacturer of Hackney Products Since 1902

1479 S. 66th Street, Milwaukee 14, Wisconsin

Branch offices in principal cities

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

No. 214 on Reader Service Card

MODULES drive indicator tubes

A new series of "Trixie" modules have been developed to operate as drivers for this company's line of "Nixie" indicator tubes. According to **Burroughs Corp., Electronic Components Div., Dept. S/A, P. O. Box 1226, Plainfield, N.J.,** the modules provide broadened temperature characteristics which facilitate use in military and industrial electronic equipment.

The modules utilize 10 NPN silicon transistors to amplify low level signals. When used with encoders, the units are capable of driving tubes directly from transistor signals that have binary outputs.

No. 395 on Reader Service Card

COOLING UNIT for airborne ECM

This compact, lightweight cooling unit was designed by **Budd Electronics, Dept. S/A, 43-22 Queens St., Long Island City, N. Y.,** to cool the magnetron and other electronic components of the AN/ALT-6B airborne countermeasure system. A single high speed motor directly drives the coolant pump and a tube axial fan. The system is designed to meet the requirements of MIL-E-5400.

Output cooling load is 1300 watts flow is 0.3 gpm of OS-45 high temperature fluid, pressure is 60 psig, and maximum coolant temperature is 100 deg C. Environmental conditions include temperature range of –55 to +55 deg C, relative humidity up to 100 per cent, and sea level to 60,000 ft altitude.

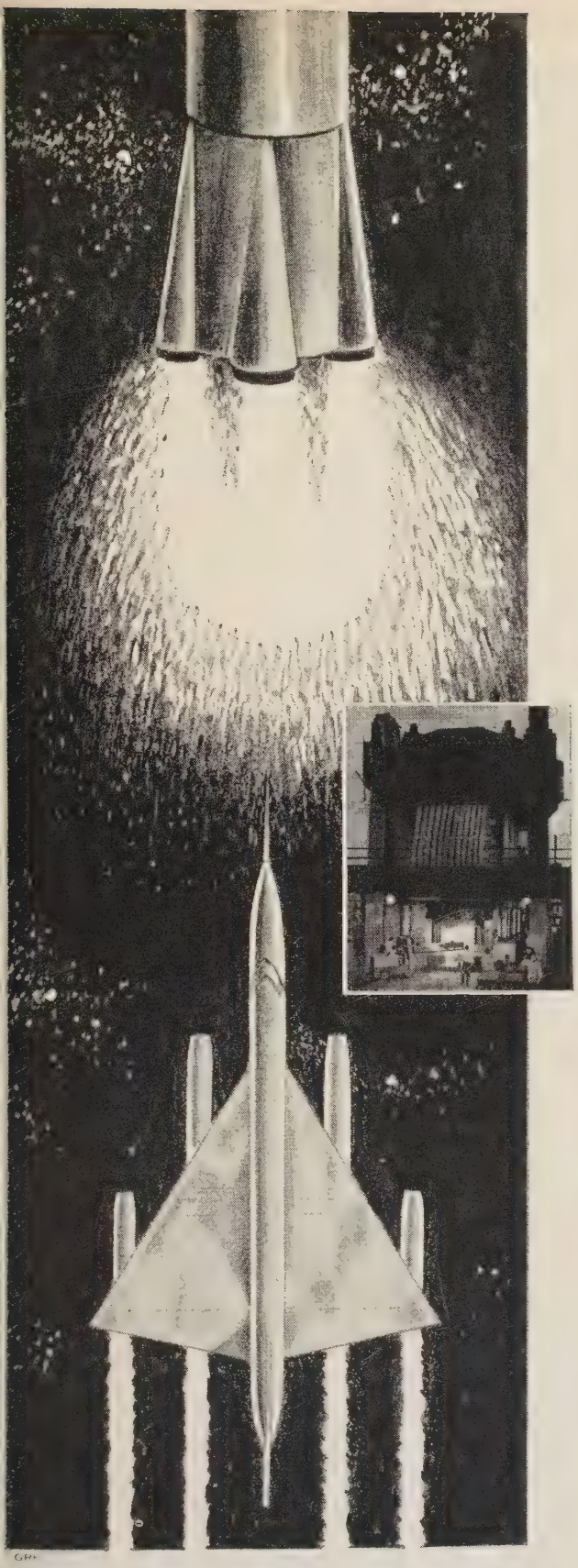
No. 396 on Reader Service Card

TELESCOPING CARRIER provides cable support

Cables connected to drawer-mounted electronic equipment can be uniformly supported, regardless of drawer position, with a cable-carrying mechanism developed by **Jonathan Mfg. Co., Dept. S/A, 720 E. Walnut Ave., Fullerton, Calif.** The carrier firmly secures cable, prevents entanglement with other stored chassis, and compactly stores cable in a minimum depth when the chassis drawer is closed.

The cable carrier mechanism occupies approximately 1 in. of storage space when retracted and is designed to meet applicable military specifications.

No. 397 on Reader Service Card



Forging a metal spectrum for any flight environment

Whether design criteria be Mach 2 or escape velocity — the part a wing spar or rocket motor nozzle — most of the significant advances in forging conventional, exotic and refractory materials come from Wyman-Gordon. Here, technical breakthroughs in size, complexity and strength-to-weight ratios of forged airframe hardware and propulsion components have materially raised performance ceilings for every type of vehicle — global bomber to deep space probe capsule. Always impatient with state-of-the-art concepts, Wyman-Gordon engineers and metallurgists constantly explore ways to bring hitherto "unforgeable" metals and alloys into operational use — broadening the spectrum of ultimate-performance materials available for advanced vehicle designs. Consultation on your project requirements can help achieve better correlation of materials to service environment.

CURRENTLY FORGING THESE AERO-SPACE MATERIALS

Aluminum	Beryllium
Titanium	Molybdenum
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Inco 718	René 41
Astroloy	Waspaloy
Stainless steels	Vacuum-melt alloys
Nickel-base alloys	Iron-base, high-temperature alloys
High-strength die steels	20-27 Nickel steels

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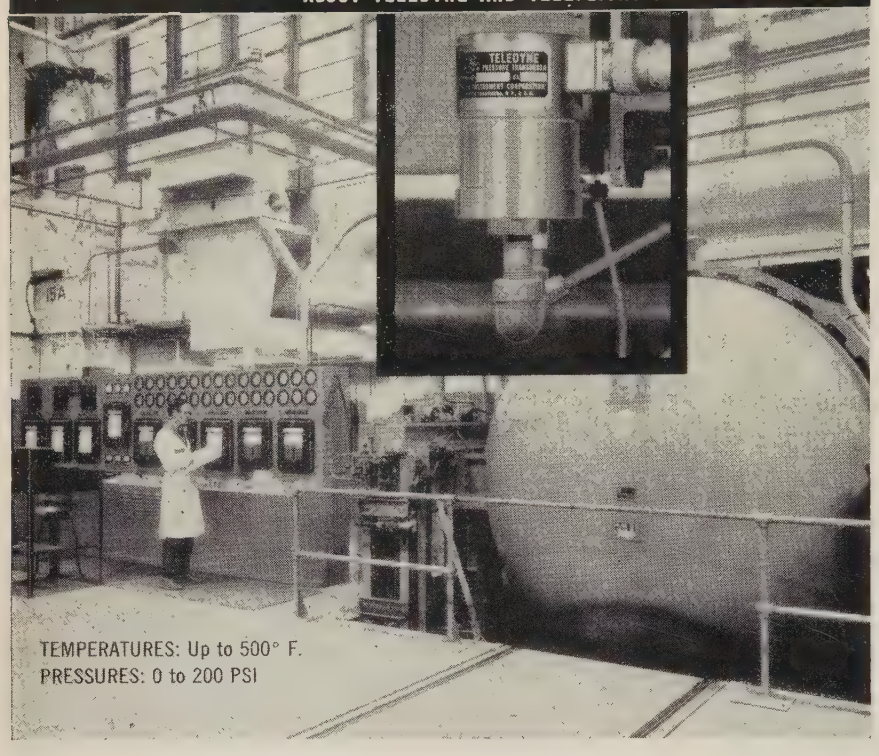
No. 215 on Reader Service Card

Taber®

TELE-NEWS

ABOUT TELEDYNE AND TELEFLIGHT PRESSURE SYSTEMS



Taber Transducer keeps close tab on autoclave air pressures at Twin Coach

The dependability and accuracy of Taber Bonded Strain Gage Pressure Transducers are pointed up in the manufacture of bonded aircraft assemblies at Twin Coach Co., Buffalo, N. Y.

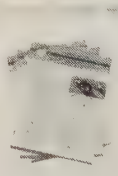
Assemblies are bonded at temperatures up to 500° F inside a 12′ x 37′ autoclave where atmospheric conditions must be precisely controlled. Mounted externally to permit this high temperature application, a Taber Model 217 Teledyne Pressure Transducer senses autoclave air pressures from 0 to 200 psi, accurately and continuously. *Quality of manufacture is thus insured!*

Among the many performance pluses of Taber Transducers are high frequency response, minimum hysteresis, infinite resolution and low sensitivity to temperature effects, vibration and shock. Models are produced for a wide variety of test, ground support, or airborne applications, with pressure ranges from 0-50 to 0-10,000 psi.

For detailed information on Taber Transducers, mail this coupon attached to your letterhead.

TO: TABER INSTRUMENT CORPORATION
AEROSPACE ELECTRONICS DIVISION SECTION 36
107 Goundry Street, North Tonawanda, N. Y.

Send detailed information on Taber Teledyne and Teleflight bonded strain gage pressure transducers.



name _____ title _____

company _____ dept. _____

address _____

city _____ zone _____ state _____

DEMAGNETIZER for heavy duty use

This tape head demagnetizer will remove permanent magnetism, reduce noise level, reduce harmonic distortion, improve signal-to-noise ratio, insure high frequency response, and reduce hum of tape head, says **Microtrain Co., Inc., Dept. S/A, 145 E Mineola Ave., Valley Stream, N. Y.**

A special finish is provided on the pole piece to prevent marring of the record head surface. The unit is molded of high impact epoxy, sealed for life, and is designed for extra rough and heavy duty use. Weighing 7 oz, it is 4 in. long by 1½ in. in diameter.

No. 398 on Reader Service Card

DELAY LINES for digital memories

Glass ultrasonic delay lines that serve as high-speed digital memories for computers and data processing equipment have been developed by **Corning Glass Works, Dept. S/A, Corning, N. Y.** Serial memories exhibit information rates of 3 to 20 megabits per sec.

The company has produced a memory element that operates at data rates between 10 and 20 megabits per sec with a delay time of 50 microsec. Delay times as high as 150 microsec have been achieved. The delay medium for the components is "zero TC" glass which will accept a bit length of 20 nanosec.

No. 399 on Reader Service Card

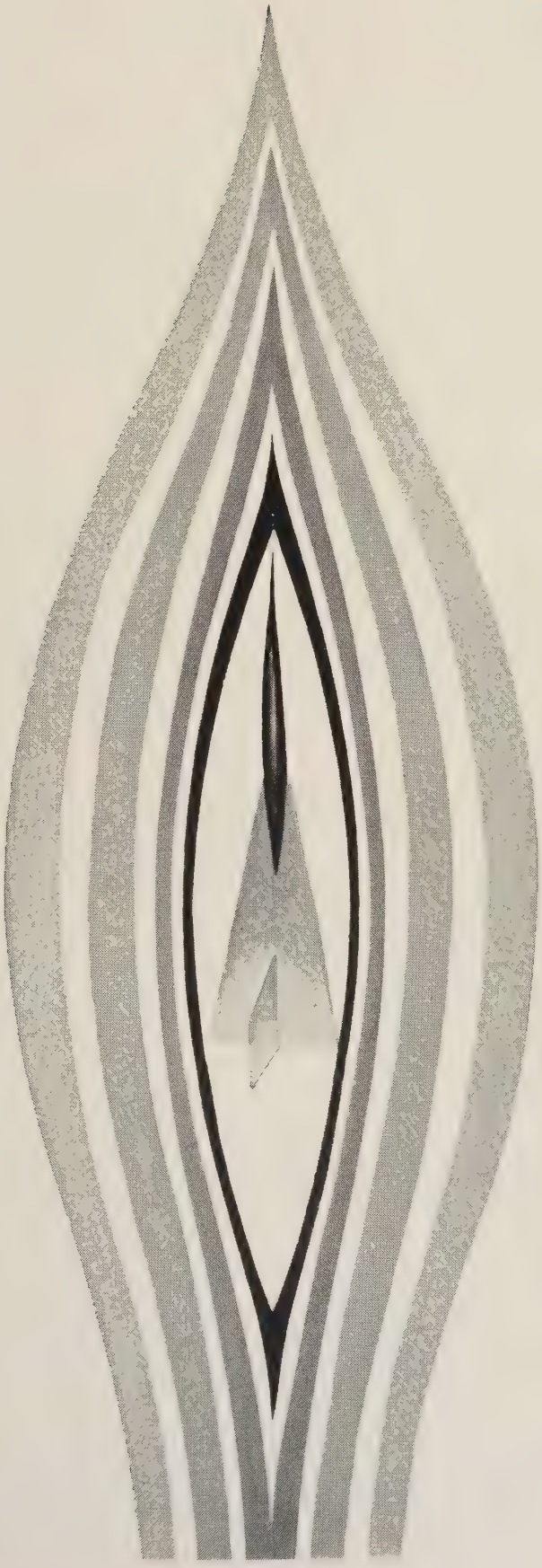
ENCODER uses U-scan technique

The CG-733 analog-to-digital shaft position encoder, using U-scan technique, is now available from **Datex Corp., Dept. S/A, 1307 S. Myrtle Ave., Monrovia, Calif.** The encoder provides non-ambiguous binary outputs of 128, 8192, and 524,288 counts. with an accuracy of ±1 count.

Internal diodes have been eliminated and there is no drop in output from bit to bit. Except for a small bistable drive circuit, all brush selection logic is performed within the disc design. Where only digit information is required, only half the number of brushes normally used in V-scan encoders are needed. The encoder is capable of either positive or negative interrogation without alteration.

No. 400 on Reader Service Card

No. 216 on Reader Service Card



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If you qualify and would like information regarding specific assignments and living conditions in Wichita, write in strict confidence to Mr. Melvin Vobach, Dept. OMO, The Boeing Company, Wichita Division, Wichita 1, Kan.

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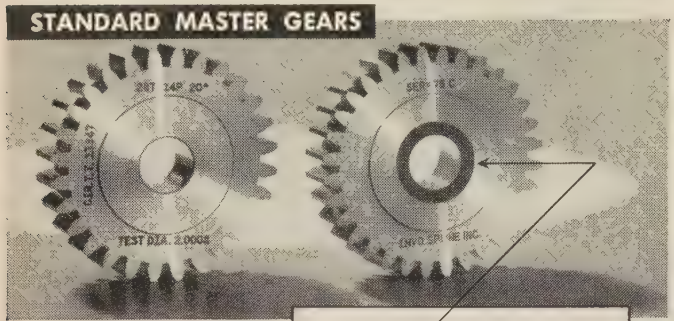
ULTRA-HIGH PRECISION

FINE AND COARSE PITCH

STANDARD MASTER GEARS



FINE PITCH MASTER GEARS are now available with a TUNGSTEN CARBIDE BUSHING which increases gear life many times by maintaining the original bore accuracy.

IMMEDIATE DELIVERY FROM STOCK

- 14½° and 20° Pressure Angles
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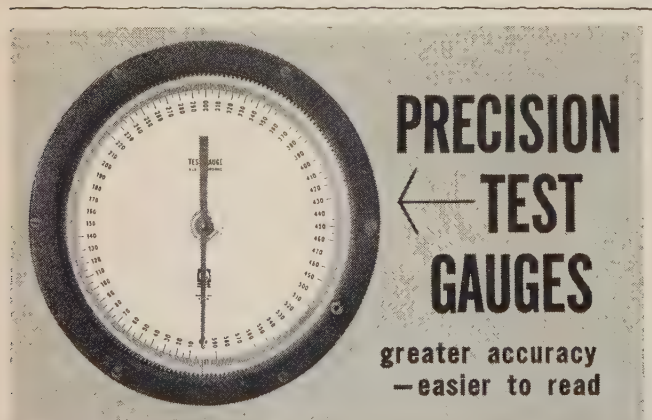
Send for Stock List!

No. 217 on Reader Service Card



PRECISION ← TEST GAUGES

greater accuracy —easier to read

8½" dia. Dial	12" dia. Dial	24" dia. Dial
25" scale length	37" scale length	70" scale length

Guaranteed accuracy ± .15%, including factors of temperature, hysteresis and calibration.

360° calibration gives 33-⅓% more scale length than conventional 270° dials.

Temperature stability, tube tip bleed, and mirrored dial are standard equipment.

All gauges calibrated against measurement standards directly traceable to the National Bureau of Standards.

MARTIN

Write for Technical Brochure T2110

M/D **DECKER** *Precision Pressure Instruments Testing—Weighing— Load and Force Measurement*

MARTIN-DECKER CORPORATION *3431 Cherry Ave., Long Beach 7, Calif.*

BRANCH OFFICES: Cleveland 14, Ohio, 1787 East 24th St. - Philadelphia 7, Pennsylvania, 324-26 No. 9th St.

No. 218 on Reader Service Card

COMMAND RECEIVER controls drones

A highly reliable, miniaturized command receiver has been developed for controlling drones, pilotless aircraft and satellites. The unit can also be used for destroy purposes in missile safety operations. Designated the Veri-Min by **Leach Corporation, Dept. S/A, 18435 Susana Rd., Compton, Calif.**, this 24 oz, 17.9 cu in. unit demodulates and filters tone-modulated FM signals in the 406 to 450 mc range, and uses them to actuate control relays. It has four channels and contains four decoders, with supplemental packages to provide additional channels.

Specifications are: sensitivity of 5 uv; antenna impedance of 50 ohms; rf bandwidth at 3 db is 220 ±20 kc at threshold; noise figure is less than 17 db; power input at 28 volts is approximately 0.75 watt standby, plus 1 watt per actuated relays.

No. 401 on Reader Service Card

PARAMETRIC AMPLIFIERS for L-, S-, C-, and X-band

Low noise, stable parametric amplifiers are now available for L-, S-, C-, and X-band from **Hughes Aircraft Co., Dept. S/A, Florence Ave. and Teale St., Culver City, Calif.** The line includes an S-band non-degenerate model with a reported noise figure of less than three db, including circulator loss.

These parametric amplifiers are designed to use varactor diodes which are commercially available. Each "paramp" includes a basic amplifier body, varactor diode, circulator, pump power monitor, and klystron. A transistorized pump power supply is also available as optional equipment.

No. 402 on Reader Service Card

COAX CONNECTOR reported very small

This quick-disconnect coaxial connector, reported to be one of the smallest ever built, engages or releases with only a slight movement of the locking device.

Designated "Nu-Lok", and available from **Nu-Line Industries, Inc., Dept. S/A, 1015 So. 6 St., Minneapolis 4, Minn.**, the connector is positive-acting and will withstand extreme vibration without damage or separation. When mated, the connector will resist a sustained force of over 45 lb, says the company. The unit measures 1⅜×¼ in. and weighs five gm.

No. 403 on Reader Service Card

ELECTROSTATIC STORAGE SYSTEM has 28 input channels

The MSS-100 multirace electrostatic storage system can accumulate repetitive and non-repetitive analog data, and can provide a continuous visual readout for study. A high resolution storage tube can simultaneously store up to 28 channels of low and high speed phenomena, says the **Electrodynamic Instrument Corp., Dept. S/A, 1841 Old Spanish Trail, Houston 25, Tex.** A 17-inch, television type video monitor can display stored data for up to 20 minutes without appreciable deterioration of signal strength or quality, according to the company.

A choice of seven storage-sweep rates from 100 milliseconds is available at a vertical sampling rate of 2500 cps. Vertical timing lines may be displayed on the video monitor at 1/100 second intervals, with an accent on every 1/10 second line.

No. 404 on Reader Service Card

PIPELINE IN THE SKY

Riddle Airlines Inc. are flying Argosies up to 13 hours daily on the U.S.A.F. Logair routes. Logair is one of the world's largest scheduled cargo operations — an aerial pipeline for the quick supply of urgent military equipment. From coast to coast these new Armstrong Whitworth aircraft speed outsize military loads in their capacious 47 ft. long holds, over a network of routes covering the U.S.A. Daily schedules bridge more than 12,000 miles.

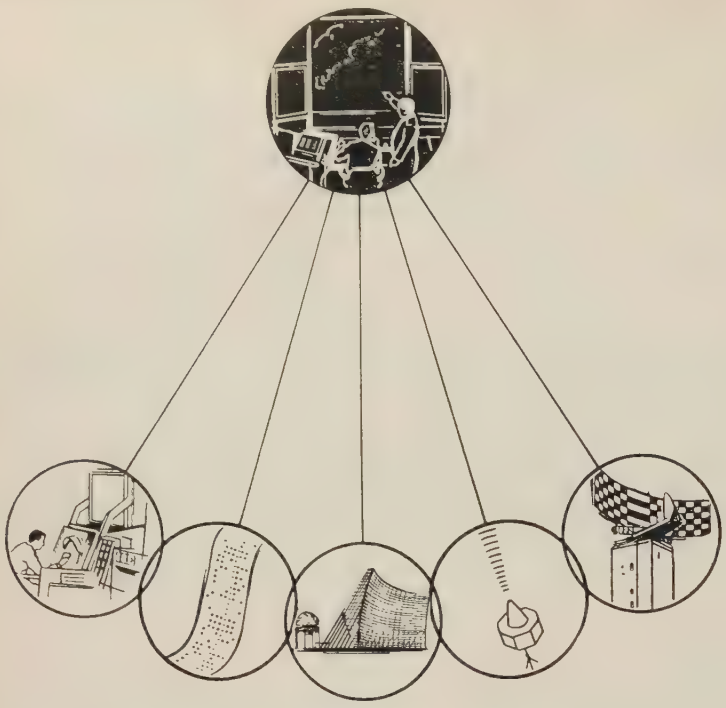
Soon, B.E.A. will be doing the same on their all-freight routes. Argosies will open up new high-speed supply lines for outsize cargoes between the U.K. and Europe.

An Argosy fleet means high speed delivery, reduced warehousing, less packaging, less handling time, less shipping cost and — above all — unusually large freight dimensions.

HAWKER SIDDELEY AVIATION

32, Duke Street, St. James's, London, S.W.1.

No. 219 on Reader Service Card



COMPRESSED TIME...AND A NATION'S NEED

The time available between alarm and decision has shrunk to minutes. In this compressed time, pertinent information must be gathered, transmitted, evaluated and displayed to the commanders through a variety of systems.

Design, development and evaluation of such command and control systems for the urgent present and the uncertain future is the vital function of MITRE.

Systems such as SAGE, BMEWS, MIDAS, Strategic Air Command and Control System, NORAD Combat Operations Center and others are all within the scope of MITRE'S system integration work for the Air Force Electronic Systems Division.

The job is challenging — the opportunity exists to break out of a single specialty — the reward is not confined to the financial.

Engineers and scientists interested in the vital field of command and control technology are invited to inquire about openings in:

- SYSTEM ANALYSIS
- OPERATIONS RESEARCH
- COMMUNICATIONS
- ADVANCED SYSTEM DESIGN
- ECONOMICS
- MATHEMATICS
- ECONOMETRICS
- COMPUTER TECHNOLOGY
- HUMAN FACTORS
- RADAR SYSTEMS AND TECHNIQUES
- ANTENNA DESIGN — MICROWAVE COMPONENTS
- AIR TRAFFIC CONTROL SYSTEM DEVELOPMENT

Write in confidence to: Vice President — Technical Operations, The Mitre Corporation, P.O. Box 208, MX30, Bedford, Mass.

THE MITRE CORPORATION

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin

OSCILLATOR operates from 18-26.5 Gc

This backward wave oscillato which operates in the 18 to 26.5 G frequency range, has been announced by **Sylvania Electric Products, Inc., Dept. S/A, 730 Third Ave., New York 17, N.Y.**

Designated type BW-4289, it is a voltage-tunable signal source for microwave receiver local oscillator use as well as for test and signal generating equipment. Minimum power output is 5 mw. This K-band tube is focused by an integral permanent magnet. It is 5 in. long, 3½ in. in diameter, and weighs 5 lb, including the magnet.

No. 405 on Reader Service Card

ANTENNA PEDESTAL is lightweight

The model 3606 azimuth antenna pedestal is so lightweight that it can be used at the top of a tower, as well as at lower levels, says **Antlab, Inc., Dept. S/A, 6330 Proprietors Rd., Worthington, Ohio.** Weighing only 300 lb, it is designed so that a mast of up to 5½-in. in diameter can be installed through the vertical axis. This auxiliary mast shares the overturning loads which may develop.

The pedestal develops a torque of 1000 ft-lb at 1½ rpm. The aluminum table is 32 in. in diameter. It may be either servo controlled or operated electromanually. Either AC or DC motors (up to 2 hp) may be used with the pedestal.

No. 406 on Reader Service Card

COAXIAL CIRCULATOR has 4 ports

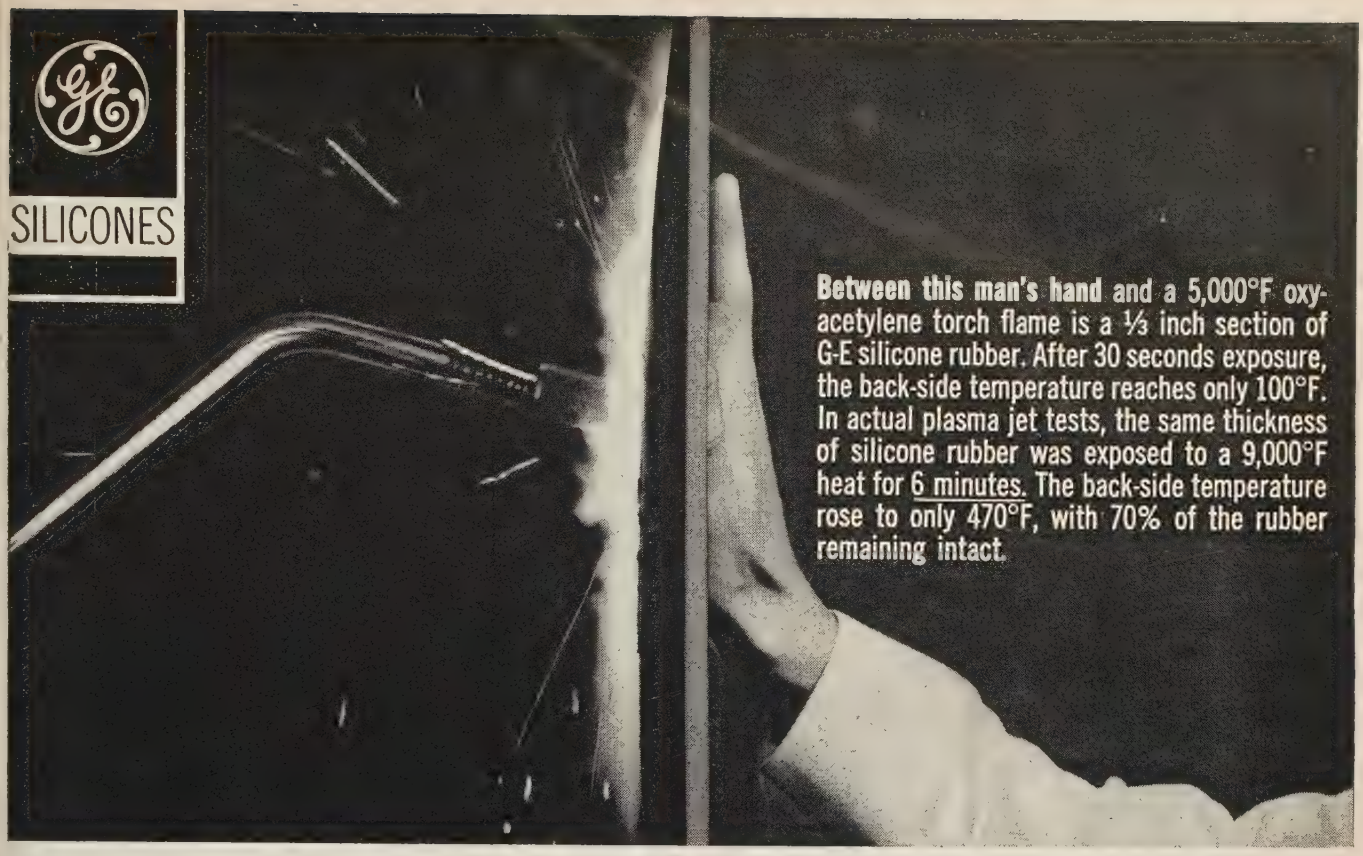
Model C-800 series of 4-port coaxial circulators has been announced by **Rantec Corp., Dept. S/A, Calabasas, Calif.** These units are miniaturized broadband types, having stable temperature performance.

Typical specifications are: isolation 20 db minimum, insertion loss 0.4 db maximum, and VSWR 1.25 to 1 maximum. Model CC-803 is for a frequency band of 4.4 to 5.6 kmc and has a built-in 2-watt termination on the fourth port. Over 40 db of isolation can be obtained over the band. Units are available in 1.5-2.0 kmc, 2.0-2.6 kmc, 2.6-3.4 kmc, 3.2-3.8 kmc, 4.4-5.6 kmc, and 5.4-6.7 kmc frequency bands.

No. 407 on Reader Service Card

Check Inquiry Form on Page 155

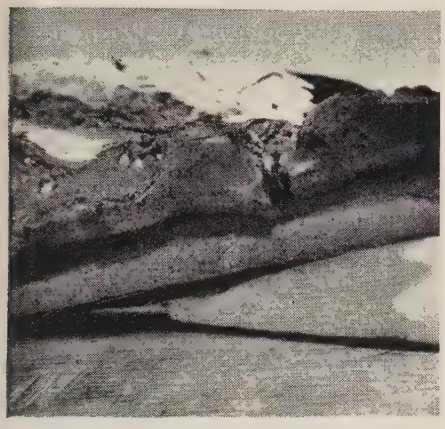
SILICONES



Between this man's hand and a 5,000°F oxy-acetylene torch flame is a ⅓ inch section of G-E silicone rubber. After 30 seconds exposure, the back-side temperature reaches only 100°F. In actual plasma jet tests, the same thickness of silicone rubber was exposed to a 9,000°F heat for 6 minutes. The back-side temperature rose to only 470°F, with 70% of the rubber remaining intact.

Thermal barrier against 5000°F flame

GENERAL ELECTRIC SILICONE RUBBER



RESULTS OF PLASMA JET TESTS AT 9,000°F

Flight Simulation
Vel.=17,000 ft./sec.
Alt.=250,000 ft.

Exposure time at 9,000°F	Back-side temperature of ⅓ inch section of G-E silicone rubber
30 seconds	100°F
2 minutes	210°F
3 minutes	300°F
4 minutes	375°F
5 minutes	430°F
6 minutes	470°F

The surface of the tested rubber section forms a hard, carbonaceous crust, while the underside remains flexible and undamaged. Preliminary tests showed the effective heat of ablation to be eight times better than presently used plastics, with one-seventh the rate of ablation and one-fourth the weight loss. Here is an excellent ablative covering with low thermal conductivity.

The above chart shows how the high thermal insulation of G-E silicone rubber is maintained during exposure to 9,000°F heat. It is also useful in mechanical and electrical applications at temperatures from —150°F to 600°F, where it remains resilient and flexible. It also maintains its excellent physical and electrical properties over this wide temperature range for extended periods.

Continued high temperature testing goes on at General Electric's Missile and Space Vehicle Department in Philadelphia. Shown above is a typical specimen undergoing plasma jet testing in an electric arc heated supersonic wind tunnel. Continuous testing like this will develop new data on the thermal and ablative uses of G-E silicone rubber.

To learn more about G-E silicone rubber, and its uses as a thermal and ablative material, write: General Electric Company, Silicone Products Dept., Section 11061, Waterford, New York.

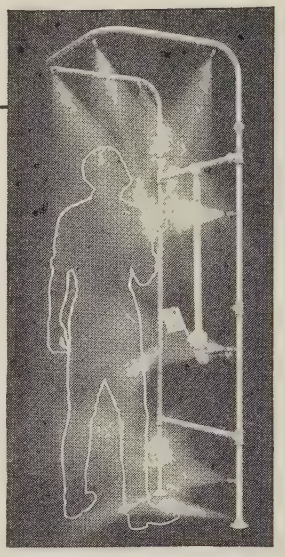
GENERAL ELECTRIC

No. 220 on Reader Service Card

You're all wet... AND SAFE!

in a HAWS Emergency Drench Shower.

Burning, corrosive, caustic contamination can inflict injuries more dangerous than blazing clothing! Contamination by acids, chemicals, volatile fuels, radioactive elements, etc., must be instantly countered by *first aid*. Immediate drenching with clear water is the first precaution against permanent injury. HAWS leads in design and production of Emergency Drench Showers! *Ask for our complete catalog.*



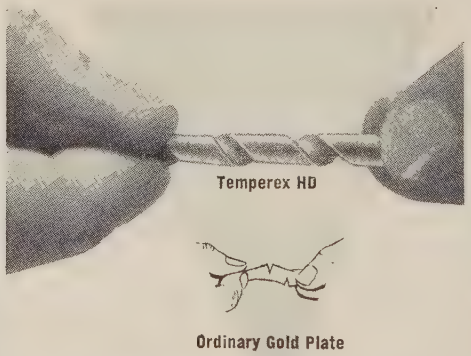
Model 8590
Multiple nozzle shower drenches victim from all angles.

Since 1909 HAWS **DRENCH SHOWERS**

a product of HAWS DRINKING FAUCET COMPANY 1443 Fourth St., Berkeley 10, Calif.

No. 221 on Reader Service Card

Extra High Purity Gold Plate!



Ordinary Gold Plate

Sel-Rex® **TEMPEREX® HD***

TEMPEREX HD electroplate meets or surpasses the most exacting specifications of the electronics industry. Its deposits of 99.99+ purity provide a uniformity of metallurgical characteristics never before attainable in gold electroplate.

Other advantages: 75 Knoop hardness; easy to solder or weld; and an exceptional ductility that permits *cork-screw twisting of electroformed strips without fracturing!*

Write for details.

*Patent applied for

SEL-REX CORPORATION
NUTLEY 10, NEW JERSEY
World's largest selling precious metal plating processes

No. 222 on Reader Service Card

TAPE PERFORATOR is medium speed

All paper or mylar tape punching requirements for data handling, reduction, processing and storage are met by a medium speed tape perforator produced by **Data Instruments Div., Telecomputing Corp., Dept. S/A, 12838 Saticoy St., No. Hollywood, Calif.** Operating at speeds to 40 columns per sec, the modular-constructed tape unit has a smooth eccentric drive.

Designed to provide in excess of 10 million operations, 5, 6, 7, or 8 code holes are used on three standard tape widths. The unit can be specified for punching speed, code levels and tape width.

No. 408 on Reader Service Card

TRIGGER DEVICE for logic circuits

The TI-41 PNPN silicon trigger device is a bistable unit rated for a forward breakover voltage of 30 ±6 volts with a maximum breakover current of 100 ua, and a maximum forward voltage drop of 5 volts at I_F of 100 ma, says **Texas Instruments, Inc., Dept. S/A, P.O. Box 5012, Dallas 22, Tex.**

It is expected that this TI-41 will find extensive use in logic circuitry, function generators, noise generators, and core driving applications. Its chief application, however, will be in firing SCRs. In this usage, lower cost SCRs can be used without having to set tight limits on the gate triggering circuit.

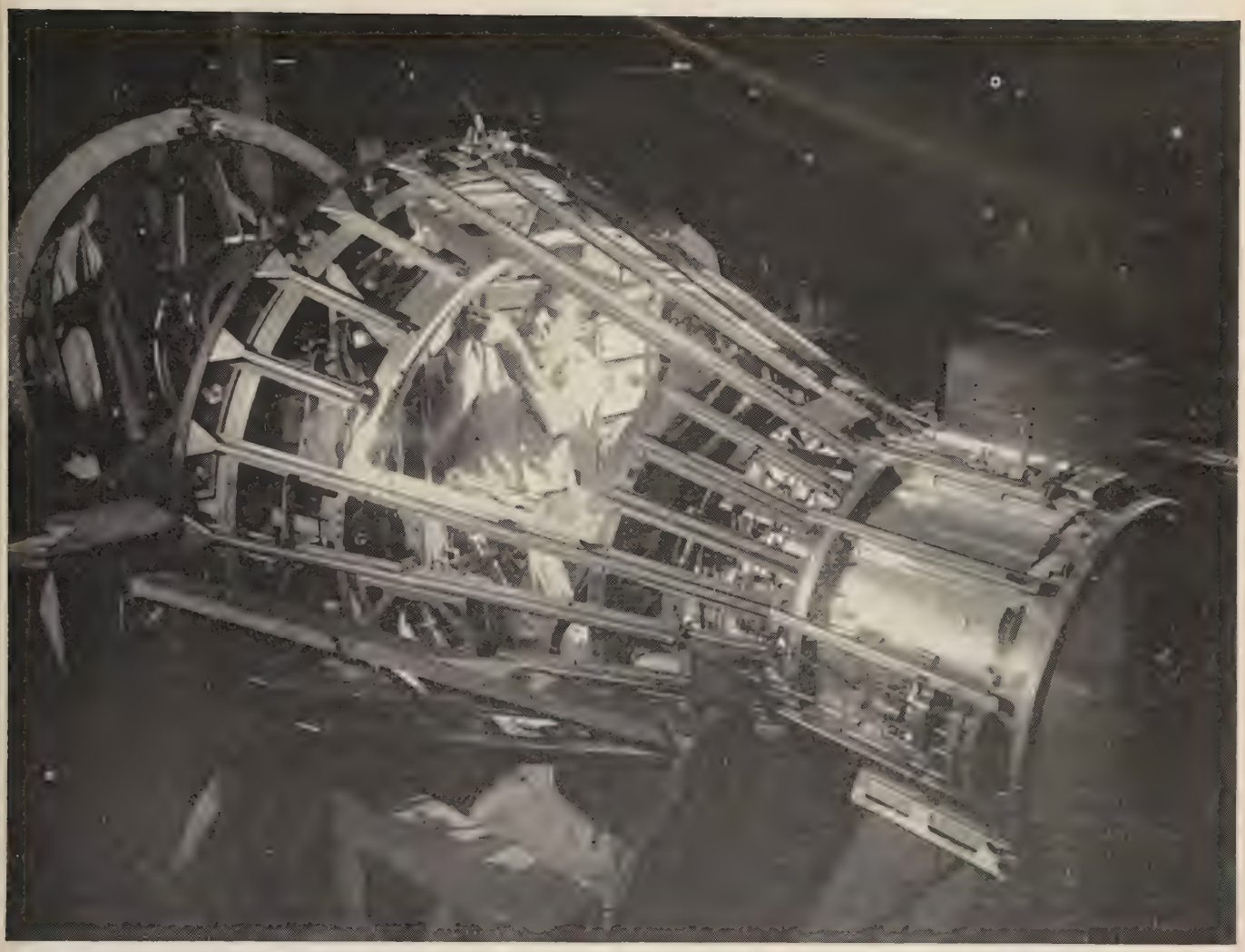
No. 409 on Reader Service Card

PHOTO DETECTOR for space navigation

This GAU-401 gallium arsenide photovoltaic detector marks the first use of photo detection capabilities of solid state devices, according to **Lansdale Div., Philco Corp., Dept. S/A, Lansdale, Penna.** The device is reported to provide high sensitivity for visible and near-infrared radiation detection.

Packaged in a modified TO-18 transistor case, it is estimated the detector is 1/20th the size of a related photomultiplier. According to Philco, the new detector is suitable for use in celestial body sensing, missile tracking, fuzing, warning, space vehicle attitude control and guidance, stellar supervision of inertial platforms, and computer readout.

No. 410 on Reader Service Card



Titanium construction clinches record of reliability with Mercury capsule!

Mercury's astronaut, and all that was at take with him, rode out the big shot afely in a titanium structure.

Project Mercury's pressurized capsule, ts antenna and parachute housings and he adapter section mating it to the booster consist basically of a titanium nner skin attached to a framework of itanium stringers and rings.

Weight saving: Titanium saved "considerable" weight over other metals of imilar strength and endurance in the all-ritical weight battle in the Mercury apsule.

Rigidity and strength at high temperatures: The titanium stringers in the apsule reach 600F during re-entry; the nner skin reaches 200F. Here is high performance and reliability . . . Mercury capsule is designed to withstand 20 G's.

Added stiffness and efficiency is gained by "rigidizing" or beading. Mercury inner skin consists of a "sandwich" structure of two layers of 0.010" commercially pure titanium. The outer layer is stiffened with corrugations, for a 150% increase in efficiency.

45,000 inches of perfect welds per capsule: In 20 production capsules, not a single rejection due to poor weld!

TMCA: your information source. The reliability on which the makers of the Mercury capsule placed their faith can work for you in design and construction of weight-critical airframe stuctures. For information on titanium application . . . fabrication . . . competent fabricators, write Technical Service Dept., TMCA.

TIMET®

TITANIUM METALS CORPORATION OF AMERICA
233 Broadway, New York 7, N.Y.
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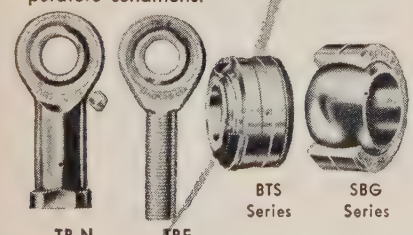
No. 223 on Reader Service Card

"Precision built for superior performance"

SPHERCO
BEARINGS & ROD ENDS

AVAILABLE IN A COMPLETE RANGE OF SIZES

If you have applications involving linkage or transfer of motion, SPHERCO Bearings can supply your needs in a wide variety of materials with a quality that will give you top performance under normal or high temperature conditions.



WRITE FOR BULLETIN 560

SPHERCO
A PRODUCT OF SEALMASTER BEARING DIVISION STEPHENS-ADAMSON MFG. CO.
2 RIDGEWAY AVE. • AURORA, ILL.

No. 224 on Reader Service Card

BEACON TRANSMITTER for missile applications

Satellite applications are reported possible with this transistorized beacon transmitter. Designed by **Cook Electric Co., Dept. S/A, 2700 Southport Ave., Chicago 14, Ill.**, it is battery-powered, and transmits an amplitude-modulated, crystal-controlled frequency.

Two or more audio modulation frequencies are used; one for identification, one for limited telemetering. The latter is variable by means of VCO and an externally connected transducer. All electronics of the unit are contained in a 4-in. cube.

No. 411 on Reader Service Card

PHOTOELECTRIC READER is less than one cu in.

A highly sensitive, miniaturized photoelectric reader, approximately ⅔ cu in. in volume, has been announced by **Melpar, Inc., Dept. S/A, Falls Church, Va.** Designated the model 150 reader, it combines a light source, lens, and photo-cell in a single unit.

The unit features a split cylindrical lens consisting of two glass cylinders separated by an opaque surface. Light rays from the lamp are refracted through the lens and pass through the beam-forming aperture. Reflected light impinges on the sensitive photocell. As reflected light intensity varies, the resistance of the sensing element also varies.

No. 412 on Reader Service Card

ATTENUATORS for x-band frequencies

A series of three attenuators have been introduced by **ITT Federal Laboratories, Dept. S/A, Fort Wayne, Ind.**, for use in x-band frequencies.

An adjustable unit has an insertion loss of less than 0.1 db, and a maximum attenuation of 40 db. A ferrite step attenuator, providing up to 50 db of attenuation, features low standing-wave ratio and low insertion loss. A third unit is a multihole-coupler fixed attenuator. When set to a desired attenuation, the coupler will retain the set value over a 20 per cent frequency band to within ±1 per cent.

No. 413 on Reader Service Card

INFRARED SOURCE is miniaturized

An infrared source weighing only three oz and measuring 0.75 in. in dia by 1.5 in. long has been developed by **Special Devices, Inc., Dept. S/A, 16830 W. Placerita Canyon Rd., Newhall, Calif.** Applications include instrument and optical system calibration, missile and space vehicle tracking and control, target tracking and field testing.

The energy of the source may be modulated without attenuation of signal strength. The electromagnetic radiation emitted approaches 99.9 per cent of a black body source. Usable radiation energy is maintained for over ten sec.

No. 414 on Reader Service Card

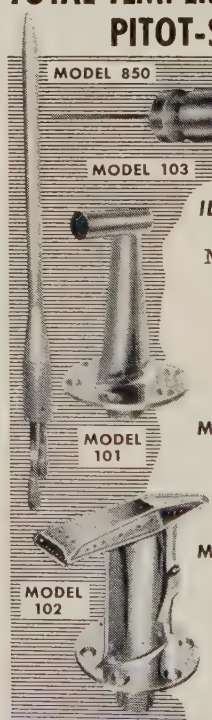
COUNTER MODULE is transistorized

A new 1 mc transistorized counter module, the DC-116, features a minimum of active components. Designed by **Burroughs Corp., Electronic Components Div., Dept. S/A, P.O. Box 1226, Plainfield, N.J.** the unit is physically and electrically compatible with the 100 kc type DC-114 counter.

Since both units utilize the shielded "Beam-X" Switch and integral tube readout, a 1 mc transistorized counting system can be designed to provide direct readout with optimum spacing. The DC-116 counter features 10 electrical outputs to provide circuit functions.

No. 415 on Reader Service Card

TOTAL TEMPERATURE PROBES
PITOT-STATIC TUBES



ILLUSTRATED MODELS

MODEL 850 Meets Mach 3 requirements of MIL-P-25757A (USAF).

MODEL 103 Mach 5 total temperature probe can be used to temperatures of 1500 C°.

MODEL 101 Mach 3 total temperature probe. Meets requirements of MIL-P-25726 (USAF).

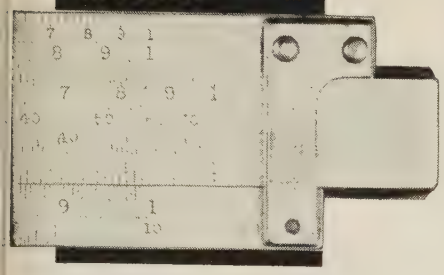
MODEL 102 Mach 3 Deiced total temperature probe. Accurately measures total temperature during deicing.

Write for Short Form Catalog No. 66030

REC
ROSEMOUNT ENGINEERING COMPANY
4912 West 78th St.
Minneapolis 24, Minn.

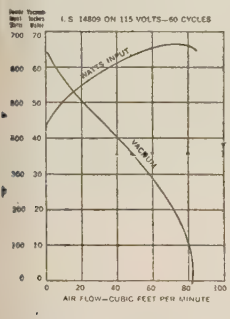
No. 225 on Reader Service Card

Fractional Horsepower Motors



Lamb® Helps You Select The Right Vacuum Cleaner Motor

9/16 HP, 5-11/16" fan case diameter



IS-14750 thru ventilated

APPLICATION: Domestic portable cleaners.

IS-14809 by-pass ventilated

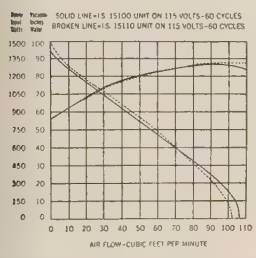
APPLICATION: Wet pick-up portable cleaners and central cleaning systems.

Service Life: Moderate
Cost: Low
Bulletins 101 & 201

NEW

1 HP, 7-3/16" fan case diameter

APPLICATION: Central vacuum systems in particular, also portable commercial wet and dry cleaners.


SOLID LINE=I.S. 15100 UNIT ON 115 VOLTS-60 CYCLES
BROKEN LINE=I.S. 15110 UNIT ON 115 VOLTS-60 CYCLES
AIR FLOW-CUBIC FEET PER MINUTE

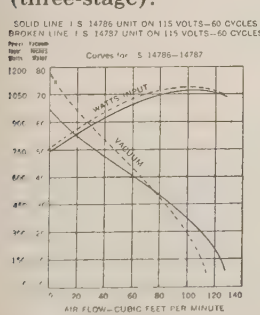
IS-15100 Diffused air discharge

IS-15110 Single air discharge

Service Life: Moderate
Cost: About twice cost of 9/16 HP
Bulletins 251 & 252

7/8 HP, 7-1/2" fan case diameter

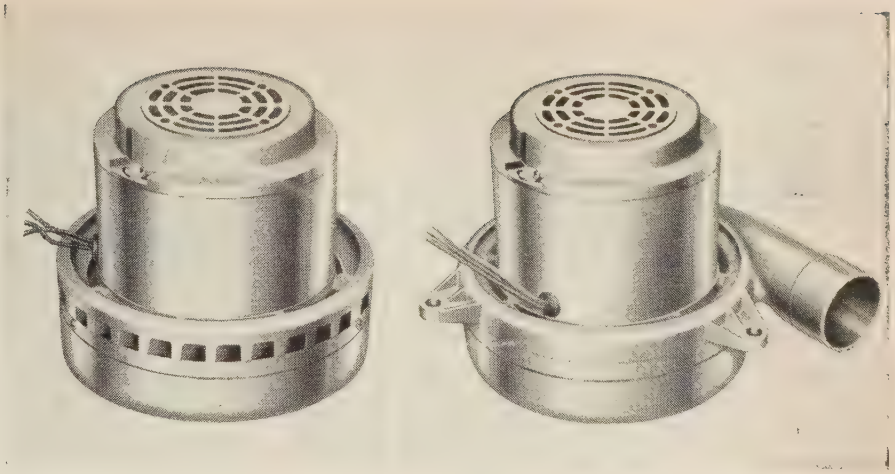
APPLICATION: Portable Heavy Duty Commercial Cleaners and Central Systems (three-stage).


SOLID LINE I.S. 14786 UNIT ON 115 VOLTS—60 CYCLES
BROKEN LINE I.S. 14787 UNIT ON 115 VOLTS—60 CYCLES
Curves for I.S. 14786—14787
WATTS INPUT
VACUUM
AIR FLOW—CUBIC FEET PER MINUTE

IS-14786 2-Stage

IS-14787 3-Stage

Service Life: Long
Cost: About 3 times cost of 9/16 HP
Bulletin 301



IS-15100 (Diffuser Discharge)

IS-15110 (Single Air Discharge)

Special Requirements of Central Vacuum Systems Met by New High Performance Motor

Existing vacuum motors have been designed to perform best when incorporated into portable vacuum cleaners of standard types and sizes. Such motors are built to produce highest efficiency under air flow conditions that exist in normal domestic and industrial cleaning service and where hoses are of normal length and diameter.

On special applications, like central vacuum cleaning systems that utilize extremely long cleaning hoses, and where tubing losses are present, a special motor is required. To meet this need, Lamb now offers a vacuum motor which will maintain a relatively high vacuum with a modest amount of air flow. The result: these motors operate at high efficiency in the high vacuum range without sacrificing air flow performance under low vacuum conditions.

INPUT – 10 AMPERES at 115 VOLTS

For economical, cleaner design, this rating at Underwriters' test point was selected as the input limit. This allows use of line cord not exceeding number 16 type SJ and control switches of 10 ampere rating.

NEW TAPERED BLADE DESIGN

On central systems which employ centrifugal dirt separation, a small amount of fine dirt and lint must pass through the fan and is discharged outside of the building. For maximum efficiency, this type of fan blade is designed with a long backward curving sweep which, however, may accumulate fine dirt due to centrifugal action. This dirt builds up to a point where starting acceleration dislodges dirt from one blade, resulting in unbalance, noise, and vibration. Special steep angle blades have been used but they also have serious performance limitations.

Lamb research has developed a moderately steep blade angle plus a tapered form. The result is a compromise that yields excellent performance and all but eliminates the dirt loading problem.

CHOICE OF AIR DISCHARGE SYSTEMS

Lint accumulation is minimized and high vacuum is improved in the IS-15110 with a single tangential discharge pipe. This allows for easy connection to a discharge piping system, if desired.

The IS-15100, by discharging air through slots in the fan case, results in better noise suppression.

FAN-END BEARING IS PROTECTED BY AIR COOLING

Motors in central vacuum systems are often required to operate for long periods of time under sealed conditions – which results in a high temperature rise in the fan system. In ordinary by-pass type motors, the electrical parts have a separate cooling system, but bearings in the adjacent fan case often become hot enough to destroy the lubricant. Early failures can and do result. Lamb's new motor prevents this by providing a unique ventilating system which directs cooling air over the fan-end bearing and protects the motor from harmful heat built-up within the fan case. For complete details, write to Lamb Electric Company, Kent, Ohio – ask for bulletins shown at left. *Also available – explosion-proof model. Ask for bulletin 401.*

#2

of a New
TECHNICAL
REFERENCE
SERIES

TO BE PUBLISHED DECEMBER 1961

Aerospace Electronics

DESIGN GUIDLINES:
Space and Airborne
Electronic Systems

AVAILABLE TO ALL INDUSTRY TECHNICAL MANAGEMENT CONCERNED WITH AEROSPACE ELECTRONICS

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All requests must be in New York office by October 30, 1961

The Reference Will Feature

- Technical Planning Parameters
- Techniques of Aero/Space-Borne Electronic Design
- Circuitry Design
- Packaging Design Factors
- Designing For Environmental Conditions
- Component Selection Considerations

Space/Aeronautics

A CONOVER-MAST PUBLICATION

205 EAST 42nd STREET, NEW YORK 17, N. Y.

SHIFT REGISTER uses thin magnetic film

The development of thin magnetic film shift registers has been announced by **Servomechanisms, Inc., Dept. S/A, 200 N. Aviation Blvd., El Segundo, Calif.** The registers use a magnetic domain interaction or domain boundary extension phenomenon inherent in magnetic films. This pheomenon yields registers in which data processing is performed completely inside the film.

The units consist of substrates measuring 1 x 3 in., onto which a mixture of nickel and iron is deposited. Suitable flux change sensing loops and dielectrics are also deposited. When fields are produced and applied to the film in proper sequence binary information, defined by the orientation of magnetic dipoles, can be processed. Present units have a capability of 23 bits and yield up to 2 mv output signal.

No. 416 on Reader Service Card

TRANSMITTER weighs less than 20 oz

A small, all solid state, crystal-controlled telemetry transmitter, developed by **DuKane Corp., Dept. S/A, St. Charles, Ill.**, is now being used in telemetry and tracking operations. This N15A125 model is completely transistorized and weighs less than 20 oz, including potting.

General specifications for the unit include: frequency—135 mc band; power supply—20-24 volts; output—500 mw at 20 v, 1000 mw at 24 v; efficiency—30 percent; operating temperature—0 to 50 deg C; stability—1 part in 10_{-6} for 5/5 deg C increment.

No. 417 on Reader Service Card

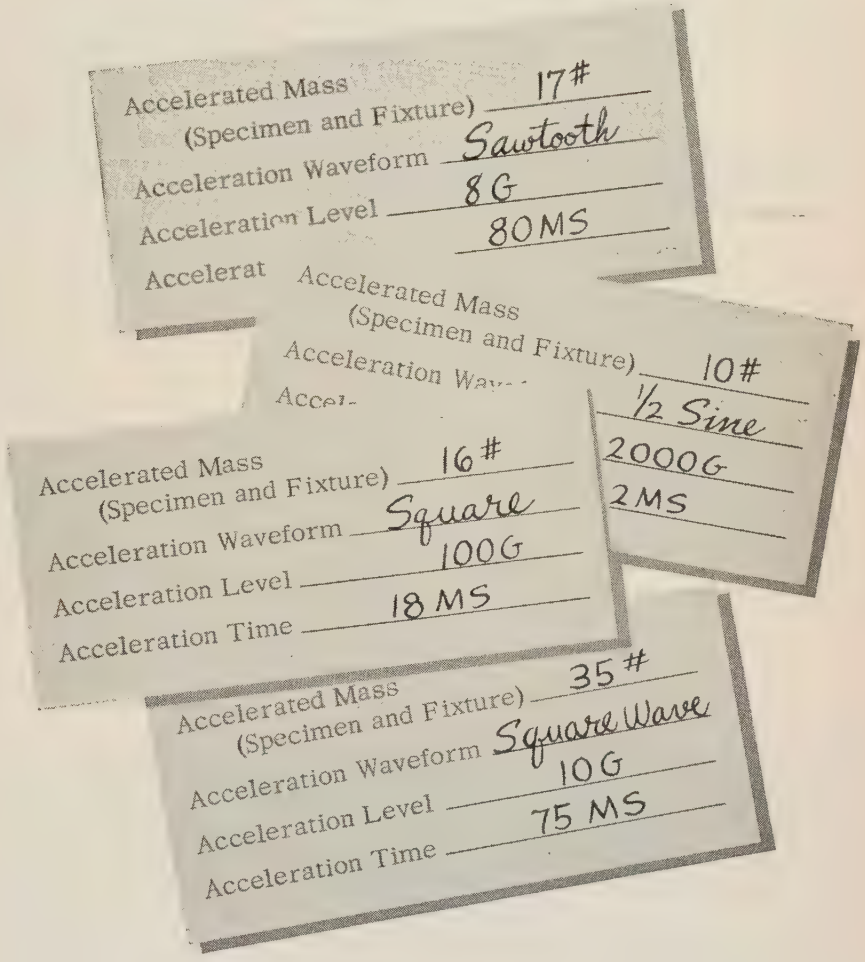
RECEIVER handles 20 channels

A fully transistorized receiver-decoder which accomodates up to 20 command channels for remotely controlling missiles or pilotless aircraft has been introduced by **Babcock Electronics Corp., Dept. S/A, 1640 Monrovia Ave., Costa Mesa, Calif.** The BCR-50 operates in the 406 to 549 mc range on the 20 standard IRIG tones used for radio control.

The receiver permits simultaneous use of six channels, each channel with ±20 kc deviation. A signal strength of 10 uv is sufficient to energize all six channels with 7.5 watts of input power. A crystal oscillator circuit maintains 0.01 per cent frequency stability.

No. 418 on Reader Service Card

Shock Tests only HYGE can perform reliably... repeat reliably



11 MS ½ sine, 6 MS sawtooth, 10 MS square . . . these are typical shock pulses frequently encountered in today's military specifications and routinely tested with CVC HYGE. Military specs also call for many special shock waveforms which have been accurately performed and repeated only with HYGE. A few of these are shown above.

Choose from 3 HYGE models . . . laboratory or production line . . . with thrust capacities up to 40,000 lbs. force . . . and acceleration to 2000 G. Each features HYGE's unique adaptability to the widest range of shock tests, to meet your present and *future* shock test needs.

Write for HYGE Bulletins, or outline your requirements and we'll make a recommendation.

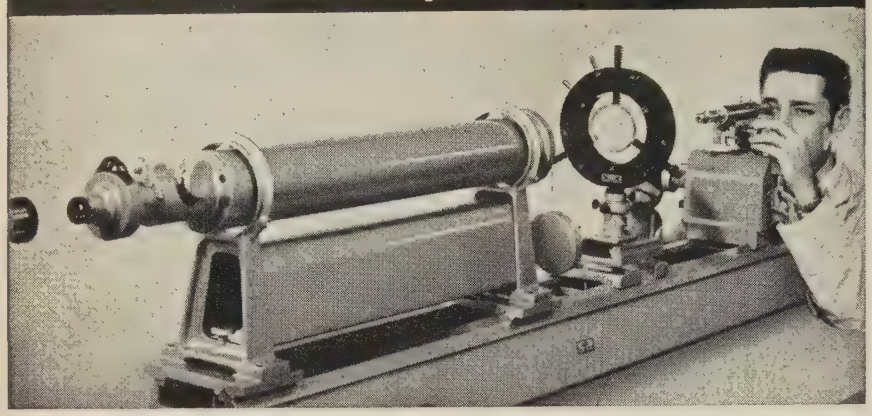
Consolidated Vacuum Corporation

ROCHESTER 3, NEW YORK

A SUBSIDIARY OF CONSOLIDATED ELECTRODYNAMICS/BELL & HOWELL

No. 227 on Reader Service Card

Gaertner Precision Optical Bench Assembly



Useful in checking optics and for experimental instrumentation setups

The Precision Optical Bench is a versatile measuring instrument consisting of a lathe-bed-type base, light source, collimator with interchangeable filters and targets, nodal slide and microscope with three-dimensional adjustment. Focal lengths, resolving power and the various aberrations of optical parts and systems can be measured.

The several components can be used independently for special test setups, mock-ups and experimental instrumentation — providing linear and angular motions and measurements, alignment and stable support.

Double and single rod benches and a large selection of carriages, holders and supports provide a complete selection from which to choose.

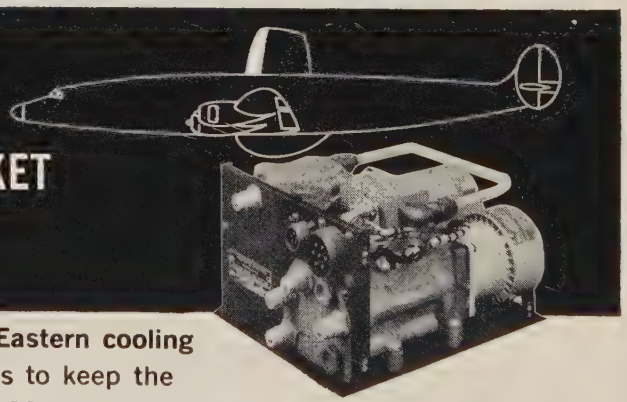
Gaertner offers a wide range of optical and measuring instruments, including special modifications, design and manufacture of special instruments and optical systems, and manufacture of subassemblies and instruments from customer sketches and drawings.

Send for bulletin 156-59

Gaertner SCIENTIFIC CORPORATION 1270 Wrightwood Ave. Chicago 14, BU 1-5335

No. 228 on Reader Service Card

ABOARD A RADAR PICKET PLANE



. . . a new Eastern cooling system helps to keep the Philco APS-103 search radar on the lookout for bogies and bandits. The liquid cooling unit has a capacity of 1600 watts, but weighs only 15 lbs., and fits into a compact 5-9/32" x 9-7/8" x 7-7/8" volume. Designed for operation to 50,000 feet, it features an ingenious internal manifold which makes for simplicity, reliability, and which eliminates most internal connections. If you need efficient, miniaturized light weight cooling units for airborne electronics cooling, call on Eastern. Eastern is your perfect source for liquid tube cooling units for capacities from 50 to 20,000 watts.

Eastern Aviation Products

EASTERN INDUSTRIES
100 Skiff Street, Hamden 14, Conn.

West Coast Office: 4203 Spencer St., Torrance, Calif.

No. 229 on Reader Service Card

AMPLIFIER has stability of 10 uv

A solid-state chopper and oscillator in this all-transistorized operational amplifier provide a stability of 10 uv in 24 hours, says **Boonshaft and Fuchs, Inc., Dept. S/A, Hatboro Industrial Park, Hatboro, Pa.** Designated the TR-1, it has a loop gain of 10_7.

Output power from 0 cps to 1 kc is ±50 v at 20 ma. For a 25-volt output, current is 100 ma. Input impedance is about 1 meg. Open loop output impedance is 250 ohms—for a loop gain of 10, output impedance is 0.1 ohm. Complete with case, the unit weighs less than 2 lb.

No. 419 on Reader Service Card

INTERFERENCE FILTERS for visible wavelength

A new line of optical interference filters with band-pass and "spike" characteristics in the spectral region from 0.38 to 0.8 microns has been developed by **Infrared Industries, Inc., Dept. S/A, Waltham, Mass.** Spike filters feature bandwidths of one per cent of peak wavelength, with 60 per cent or better transmission of center wavelength radiation.

Band-pass filters reflect radiation of shorter wavelength than the nominal pass band, and may be blocked to specification on the long wavelength side. Special filters, also available, include extemely wide-pass filters and spike filters with pass bands as little as 0.1 per cent of center wavelength

No. 420 on Reader Service Card

MAGNETIC MEMORIES feature 5 usec address

Type 3300 magnetic memories units with storage capacities from 128 to 4096 words, with 4 to 64 bits per word, are now available from **Rese Eng., Inc., Dept. S/A, A & Courtland Sts., Philadelphia, Pa.** Operating with address cycle times as low as 5 usec, the units accept digital data, store the information and can be supplied with binary or binary coded decimal address.

Input signals to the units may be at 0 or −6 volts. Output data is taken at a level from a flip-flop register. Ferrite core stack plug-ins are used as the memory storage medium. Operating temperature range is 0 to 50 deg C, without external cooling.

No. 421 on Reader Service Card

Scheduled for the Moon ...and Beyond

Bell Aerosystem's powerful Agena Rocket Engine, a reliable propulsion unit for a steadily increasing family of space vehicles.

... with ROKIDE coating protecting the nozzle*

In the successful performances of the Agena Rocket Engine and other space propulsion units, Norton ROKIDE spray coatings have provided protection against the extreme temperatures and erosion of rocket blasts.

Used by many leading missile manufacturers and proved on many of today's space craft, ROKIDE "A" aluminum oxide and ROKIDE "Z" zirconium oxide provide maximum protection with minimum weight.

ROKIDE coatings, including special coatings for varying requirements, are available from Worcester, Mass., or Santa Clara, Calif. — or from licensed applicators in key cities. For further facts write to NORTON COMPANY, Refractories Division, 649 New Bond Street, Worcester, Massachusetts,

*Trade Mark Reg. U. S. Pat. Off. and Foreign Countries.

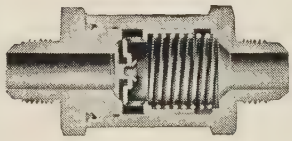
NORTON
REFRACTORIES

Crystallizing ideas into products

No. 230 on Reader Service Card

ground support and test equipment

REPUBLIC VALVES

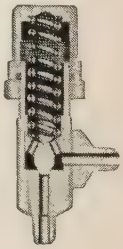


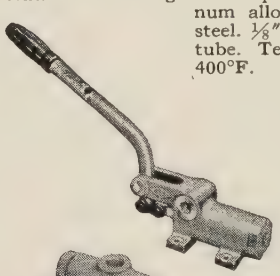
FREE-FLOW CHECK VALVES

No leakage. 3000 psi. Very low pressure drop. Can be furnished to open at ¼ to 35 psi. Brass, stainless steel, or aluminum alloy. ⅛" to 2" pipe or tube. Temp. range -65° to 200°F.

RELIEF VALVES

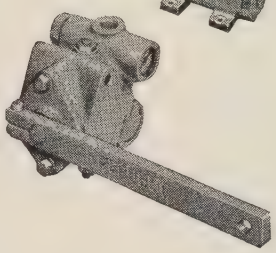
Quick unloading, smooth operation. Guided shut-off piston with stainless steel or Nylon seat. Pressure range to 4000 psi. Brass, aluminum alloy, or stainless steel. ⅛" to ¾" pipe or tube. Temp. range to 400°F.





HAND PUMP

For hydraulic applications on missile carrier and support equipment. Double-acting. 2 cu. in. displacement per cycle. 1000 psi. working pressure. Aluminum alloy body, stainless steel trim. -65° to 160°F.

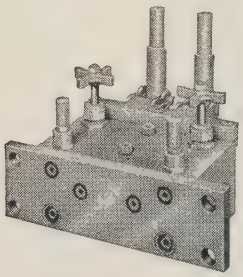


LEVELATOR VALVE

For automatically maintaining height and level condition in any vehicle with air spring suspension. Controls swaying in transit, and off-level position while standing. Applicable to trucks, buses, trailers, carriers, cranes, etc.

LO-TORQ SELECTOR VALVES

Smooth, easy operation, with low turning torque because of pressure balancing design. 0 to 6000 psi. Bronze, steel, or aluminum alloy. ⅛" to 2" pipe or tube. 2, 3, 4 ports.



DUAL HAND PUMP

2 pumps, 2 relief valves, and 2 needle shut-off valves, compactly manifolded for elevating mechanisms, hydraulic applications on ground support equipment, etc. Aluminum alloy body, stainless steel trim. -65° to 160°F.

Distributors in principal cities coast to coast

CHECK RELIEF SELECTOR GLOBE NEEDLE PLUG

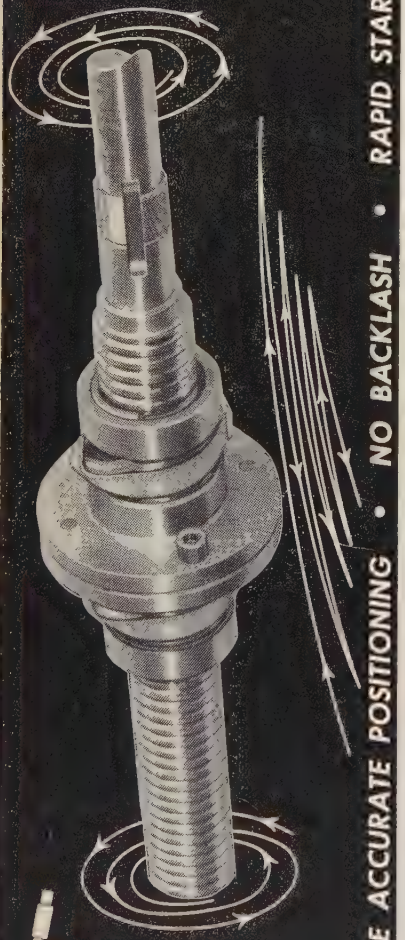
RM REPUBLIC MANUFACTURING CO.
15655 BROOKPARK ROAD • CLEVELAND 35, OHIO

No. 231 on Reader Service Card

BEAVER BALL SCREWS

Successor to the Acme screw drive and preferred in many applications to hydraulic and pneumatic systems. Guaranteed 90% efficient in converting rotary twist to linear push (or vice versa). Employs a stream of precision balls and ground lead to eliminate drag and wear in delicate instruments, aircraft, machine tools, massive wind tunnel jacks, etc. For horizontal and vertical actions, indexing, inching and traversing. Consultation and engineering service available. Write for literature.

• EXTREME ACCURATE POSITIONING • NO BACKLASH • RAPID START • ANY DIAMETER OR TRAVEL •



Beaver Precision Products INC.
CLAWSON, MICH.

No. 232 on Reader Service Card

AUGMENTER
simulates radar echos

An active radar augmenter for use in electronic simulation of radar echo characteristics has been developed by Lockheed Electronics Co., Dept. S/A, Plainfield, N.J. Designed for installation in drone or target aircraft to reinforce radar tracking facilities in missile-carrying aircraft, it receives radar transmitted signals and transmits an amplified signal back to the aircraft.

Typical gain at 9000 mc is about 70 db. Frequency range is 5 to 11 kmc. Output power is 1 watt minimum. Signal gain over the major portion of the frequency range is greater than 65 db. Input and output impedance is 50 ohms.

No. 422 on Reader Service Card

POWER OSCILLATORS
have 50 mw to 50 w output

Their line of VHF-UHF power oscillators feature RF cavities with frequency ranges from 200 to 1050 mc, and power output from 50 mw to 50 watts, says **Microdot, Inc., Dept. S/A, 220 Pasadena Ave., So. Pasadena, Calif.**

The oscillators are continuously tunable over 2 to 1 frequency bands, and have a high ratio dial with negligible backlash and a logging scale permitting a resettability of 0.002 per cent. A meter indicates proper loading. Modulation can be CW, external, pulse, internal square wave (1 kc 100 percent), or AM. Stability is ±0.1 db/hour.

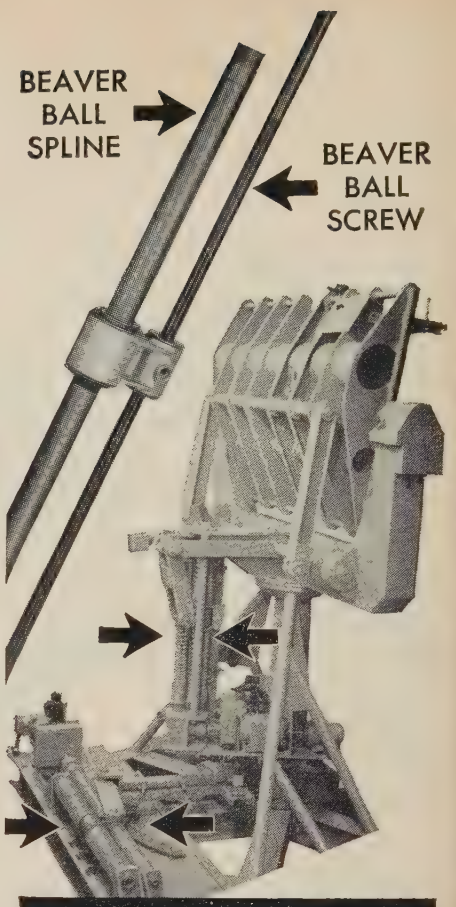
No. 423 on Reader Service Card

ANGLE INDICATOR
for remote readout

A three-channel, remote angle indicator for readout of inertial platform orientation of a guidance and navigation system is undergoing testing at **American Electronics, Inc., Dept. S/A, 9503 W. Jefferson Blvd., Culver City, Calif.** The unit consists of three separate remote channels, completely transistorized, using semiconductors and solid state passive elements.

Specifications include: input power —28 volts DC at 2.5 amps; error input—26 volts DC, 400 cps, 4-wire transmission from CX remote unit; sensitivity—±2 min deviation from null to any angle; accuracy—5 mins at any angle; repeatability—2 min; follow rate—670 deg per min.

No. 424 on Reader Service Card



B-58 HUSTLER DOPPLER ANTENNA TEST FACILITY

Beaver Ground Thread Ball Screws and Ball Splines Combine for Ultra-Precision Actuation

The demand for rigid, smooth, precise control in azimuth and elevation positioning is about as great as it comes in this production test facility designed by Equipment Division of Raytheon Company.

In machine tools and devices where high efficiency, accuracy over long distances of travel, system stiffness and compactness are desirable, Beaver engineers will be glad to work with you.

Beaver Precision Products INC.
CLAWSON, MICH.

No. 233 on Reader Service Card

VARIABLE ADAPTER eliminates potentiometers

A variable adapter which eliminates series of single-turn, in-line potentiometers is being offered by **Elm Instrument Corp., Dept. S/A, 30 Chasner St., Hempstead, N.Y.** Coupled to a single-turn pot, it changes it to a multi-turn unit. Ratio adjustments of up to 25 to 1 are obtainable.

Known as model VA-100, it is made to BuOrd OP1755 motor dimensions and uses ABEC class 5 bearings. The unit is 1⅝ x 2 in., with diameters concentric to the shaft within 0.001 TIR. Maximum backlash is 0.5 deg.

No. 425 on Reader Service Card

FERRITE SWITCH for Ka-Band

Model R-300LS ferrite switch has been added to the ferrite microwave line of **Ferrotec, Inc., Dept. S/A, 217 California St., Newton 58, Mass.** Developed as a Ka-band fast switch, it time shares two antennas with a common transmitter and receiver. Ferrotec claims the unit assures high isolation and a constant VSWR while switching between antennas.

The switch has greater than 20 db isolation 0.5 db maximum insertion loss, and a VSWR or less than 1.25. A permanent magnet can be added to allow the device to be used as a 4-port circulator.

No. 426 on Reader Service Card

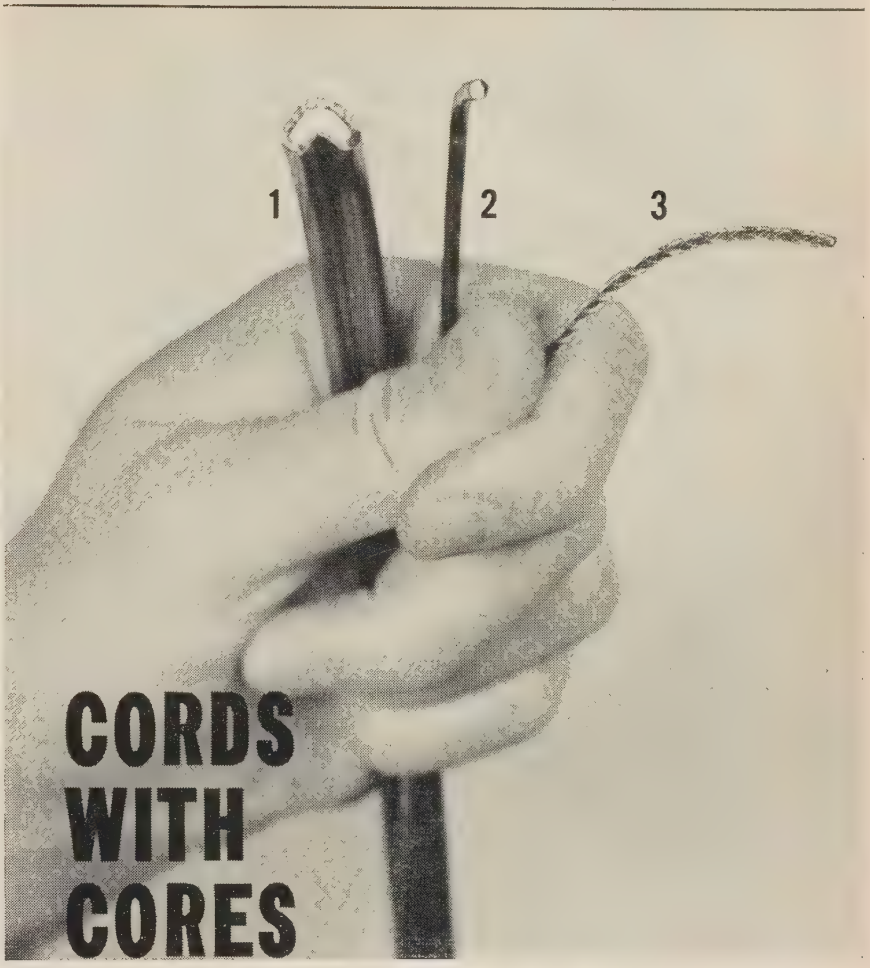
SIDEBAND FILTERS for communications

Matched pairs of precision sideband filters introduced by **Systems, Inc., Dept. S/A, 2400 Diversified Way, Orlando, Fla.**, have application for use in single-sideband transmitters and receivers for voice communications such as ship-to-shore and mobile transceivers. Both the lower sideband filter, Model LSB-1400-2.5 and the upper sideband filter, Model USB-1400-2.5, measure 1½ x 1½ x 4 in. high with a standard octal base.

The paired units feature a 1400 kc carrier frequency with a 3 db bandwidth of 2.5 kc. Carrier rejection is 20 db with at least a 50 db rejection of undesired sideband. The filters have a ripple of less than 3 db and an insertion loss of less than 6 db. Source and load impedances are 10 kilohms.

No. 427 on Reader Service Card

Ask your **Du Pont Explosive Systems Specialist** *about:*



that detonate or deflagrate

Detonating Types

1. To cut, separate, rupture: New FLSC (Flexible Linear Shaped Charge) applies explosive force directionally through V-Channel. The V-shaped flexible metal tube containing a high explosive core provides a sharply defined cutting action when detonated. This instantaneous cutting tool is useful in destruct systems, and for a variety of applications where rupture or separation is required.

2. To convey a detonation without blast damage to adjacent areas: Du Pont MDF (Mild Detonating Fuse) can contain as low as 2 grains explosive per foot or can be jacketed with a variety of materials such as lead, aluminum, plastics, wire, textiles to give greater abrasion resistance and tensile strength or decrease the noise and adjacent damage resulting from the detonation. MDF can be initiated either by an electric or non-electric means. Use of the non-electrical system eliminates extraneous or static electricity hazards and provides a method for transmitting a non-electrical, non-destructive impulse.

Deflagrating Type

3. A versatile ignition device: Du Pont "Pyrocore," a flexible cord igniter, is a small diameter, continuous metal tubing containing a detonating-ignition core. Typical specifications are:

Outside Diameter: Range in Inches—0.051-0.105
Total Weight: Grams/Ft.—4-20
Approximate Velocity: Ft./Sec.—12,000-21,000

This fast, uniform, minimum-residue igniter can be initiated either electrically or non-electrically. Why not evaluate this versatile igniter for the solution to your design problem?

Think Explosively. The Explosive Systems Specialists at Du Pont may have the answer to your design problem. For details on these and other explosive specialties write: Du Pont, 2446 Nemours Building, Wilmington 98, Delaware.

DU PONT REG. U.S. PAT. OFF. **WEAPON SYSTEMS SPECIALTIES**

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

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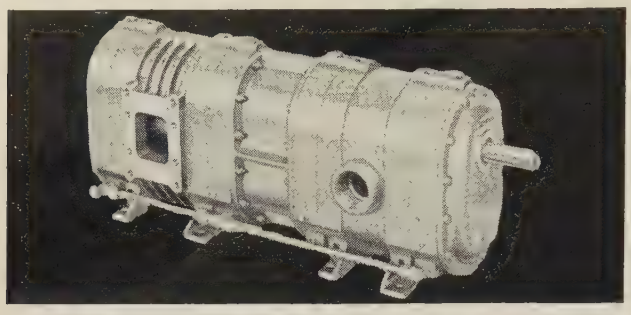
Guaranteed Oil-free Compressed Air



With M-D Blowers

When a customer required 62 CFM of absolutely oil-free air at 35 PSIG for a missile cooler, they selected the M-D model—380. M-D design eliminates the possibility of oil contamination. Other M-D features include positive displacement with no surge or vibration; compactness as a result of the unique 3-lobe rotor design; quiet operation and the reliability inherent in a simple rotating mechanism with no internal contact surfaces. Added to all these is the fact that M-D Blowers cost less than you think.

Write for complete information today.

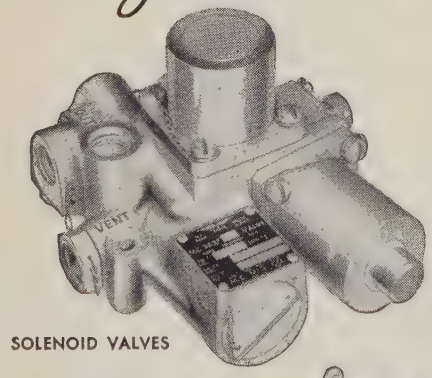
M-D BLOWERS, INC., RACINE, WISCONSIN

A Subsidiary of Miehle-Goss-Dexter, Inc.

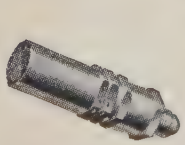
No. 235 on Reader Service Card

MC

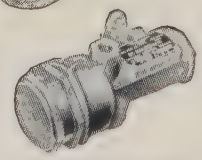
imagination + experience =



SOLENOID VALVES



RELIEF VALVES



PRESSURE REDUCERS

Other valves and systems available

SUPERIOR PERFORMANCE ECONOMICALLY

Every surface, every part, every subsystem we produce reflects the thoroughness associated with MC's famous precision work. From industrial thousandths to aero millionths you will find MC competitive in design, development, tooling, production and testing. Let our *imagination* plus *experience* help you do things right the *first time!*

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No. 236 on Reader Service Card

CONDITIONING UNITS for transducers

Two transducer signal conditioning units contain a Type PS-290 power supply and a PB-290 power and balance unit which incorporate plug-in card circuits for as many as eight channels. The PS-290 consists of a power supply card which provides excellent regulation and complete line isolation outputs ranging from millivolts to 16 volts.

According to **Microdot Inc., Dept. S/A, 220 Pasadena Ave., So. Pasadena, Calif.**, specifications for the units include output ripple of less than 500 microvolts peak-to-peak or 200 microvolts rms and line regulation of less than 0.02 per cent. Isolation is less than 0.01 microamp for 60 cycle current. Output impedance is less than 0.05 ohm.

No. 428 on Reader Service Card

MULTI-TERMINAL BASE for traveling wave tubes

A multi-terminal base assembly, consisting of a nickel cup supporting ceramic-to-metal tubular feedthroughs with an integral ceramic-to-metal input adaptor and copper evacuation tube, is being produced by **Ceramics International Corp., Dept. S/A, 39 Siding Place, Mahwah, N.J.**

For use in traveling wave tubes, it features ceramic-to-metal components which are metalized by a special process. A major factor in the production of these items is that they are brazed on ceramic jigs. The bases are rugged to withstand repeated welding and a bakeout in air at 700 deg C without leaking.

No. 429 on Reader Service Card

SIGNAL GENERATOR tunable from 400-550 mc

The model 1001 FM signal generator, continuously tunable from 400 to 550 mc, has been introduced by **R S Electronics Corp., Dept. S/A, P.O. Box 11368, Station A, Palo Alto, Calif.** Reportedly it has a frequency drift of less than 0.015 per cent/hr, with dial calibration accuracy of 0.5 per cent.

FM deviation is controllable in 0 to 35 and 0 to 350 kc ranges. RF leakage is less than 0.25 uv, and spurious outputs are limited to harmonics of the oscillator frequency, at levels at least 30 db down. Residual amplitude modulation is less than 2 per cent.

No. 430 on Reader Service Card

MULTICOUPLER for VLF, LF, MF antennas

The type NV 2 multicoupler, now available from **Rohde & Schwarz Sales Co., Dept. S/A, 111 Lexington Ave., Passaic, N.J.** covers the VLF, LF, and MF bands. Designed to feed up to 6 receivers, it has an input and output impedance of 60 ohms, a gain up to 3 db, and an interaction between outputs more than 35db below signal level.

The multicoupler uses four low-noise E88CC tubes, and provision is made for testing the tubes by a front panel meter. According to the company, failure of any one tube will reduced the gain by about 0.5 db. Weighing about 16.5 lb, it may be mounted in a standard 19-in. rack.

No. 431 on Reader Service Card

POTENTIOMETER is explosion-proof

The development of an encapsulated molded-composition potentiometer for explosion- and water-proof applications was recently announced by **Reon Resistor Corp., Dept. S/A, 155 Saw Mill River Rd., Yonkers, N. Y.** A patented perimeter track on this R1 pot allows it to be rated at 3 watts for standard applications and 2 watts for military.

It is reported to have a maximum operating temperature of 125 deg C and a life of 100,000 rotations under full load. Resistive values range from 100 to 5 meg. The unit measures 1½ in. square, and it can be supplied with either wire lead or lug terminations.

No. 432 on Reader Service Card

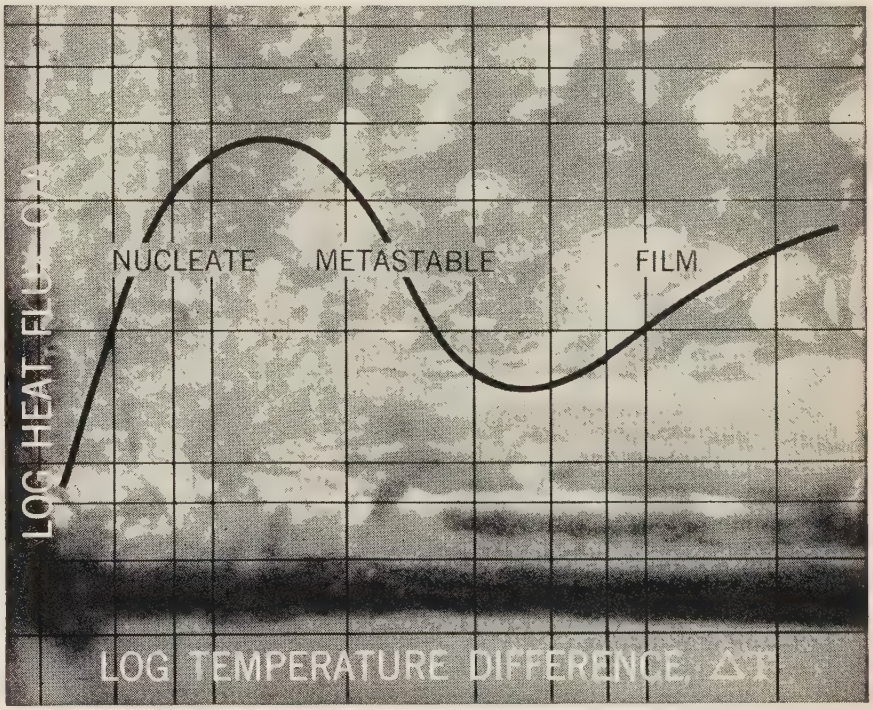
DATA STORAGE DEVICE stores 2,000,000 bits

Two new Bernoulli disks capable of storing large amount of data were recently introduced by **Laboratory for Electronics, Inc., Dept. S/A, 1079 Commonwealth Ave., Boston 15, Mass.** The unit consists of single disks of thin flexible Mylar magnetic recording tape mounted on a shaft which spins the disk between a smooth backplate and a stabilizing plate.

Basic storage of this BD-500 unit is 500,000 bits—this can be doubled by adding a second disk and head assembly. The capacity can be redoubled to 2 million by use of appropriate recording techniques. In their BD-200 series model, LFE can store 200,000 units, with facility for expansion to 800,000 bits.

No. 433 on Reader Service Card

TECHNICAL ADVANCES FROM BENDIX PIONEER-CENTRAL **CRYOGENICS**



This remarkable photo of liquid nitrogen (—320.4°F.) shows all three boiling modes—nucleate, metastable, and film boiling—on a single surface at a single heat flux.

CRYOGENIC KNOW-HOW THAT CAN PAY OFF FOR YOU!

The curve above was experimentally determined at Pioneer-Central to describe boiling heat transfer in a cryogenic fluid. It typifies our comprehensive background in the general field of heat transfer—from solid surfaces to boiling liquids.

We apply this knowledge daily to the development of important cryogenic devices, such as optical liquid sensors, LOX converters, pressure suit ventilating systems, fuel utilization and mixture ratio controls, and propellant loading controls. Find out how these facilities and capabilities can help solve *your* cryogenic problems.

Other areas of outstanding Pioneer-Central capabilities include—Inertia and Pressure Sensing Instrumentation, Life Support, Fuel Management, and Sonic Energy Cleaning.

ENGINEERS are invited to investigate the diversified opportunities at Pioneer-Central. All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

PIONEERING IS OUR BUSINESS

Pioneer-Central Division
HICKORY GROVE ROAD
DAVENPORT, IOWA

THE Bendix CORPORATION

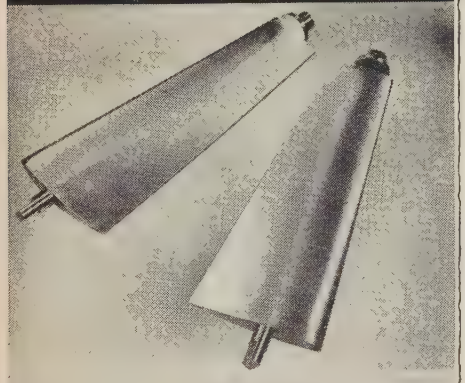
West Coast Sales & Service: Burbank, Calif. • Export Sales & Service: Bendix International Division, 205 E. 42nd St., New York 17, N. Y. • Canadian Affiliate: Aviation Electric, Ltd., Montreal, Quebec, Canada

No. 237 on Reader Service Card

Stalker

lighter weight
lower cost
precision

SHEET METAL FABRICATIONS



Much time, effort and cost go into developing the processes necessary to produce satisfactory sheet metal fabrications. *The Stalker process has been PROVEN—with the production of many quality blades and vanes, as well as other brazed sheet metal assemblies.* Stalker Orthobrazed stainless steel or super-alloy fabrications—such as compressor and turbine blades—are *dimensionally and thermally stable.*

Produced to closer tolerances than the usual machined blades, nose radii of Stalker-produced blades feature a closer dimension and uniformity from blade to blade. The Stalker forming techniques also eliminate distortion during brazing and heat treat operations. Blades hold their precise shape because of the inherent thermal stability which insures Stalker quality. The Stalker quality control and inspection system is U.S.A.F. approved.

Stalker personnel, facilities and techniques are now available for the use of firms having precision sheet metal fabrication problems.

THE STALKER CORPORATION

Phone: Bay City—TWinbrook 3-7562
905 Woodside Avenue
Essexville, Michigan

No. 238 on Reader Service Card

SIMULATOR
for x-band radar

This antenna-range simulator for flight-line testing x-band aircraft radar at close range is compact and transportable. According to **Melpar, Inc., Dept. S/A, 3000 Arlington Blvd., Falls Church, Va.**, it can simulate fixed or moving targets and can be used within a few feet of the antenna to be tested.

Called the Model 100 simulator, it uses a nutating probe of controllable speed and eccentricity which moves in the focal plane of an electromagnetic lens. Plane wave returns from a variety of directions and ranges are simulated when a suitable transponder is connected. A chamber surrounding the probe and lens absorbs unwanted internal and external interference.

No. 434 on Reader Service Card

RELAY
for printed circuits

A new micro-miniature relay with a seated height of 0.45 in. has been introduced by **Babcock Relays Div., Babcock Electronics Corp., Dept. S/A, 1645 Babcock Ave., Costa Mesa, Calif.** The low profile of the Model BR-12P has been achieved by positioning the header 90 deg to a side mounting configuration. This arrangement is said to make the relay suitable for printed circuit board applications. An additional feature of the BR-12P is its plug-in terminal design.

The dry circuit current requirement is 1 uamp at 1 mv with 100 ohm contact resistance. Contacts are rated at 3 amps at 32 volts d-c resistive load. Life tests at full load and 125 deg C have exceeded 100,000 operations. The unit is designed to meet all requirements of MIL-R-5757D.

No. 435 on Reader Service Card

KLYSTRONS
for CW illuminators

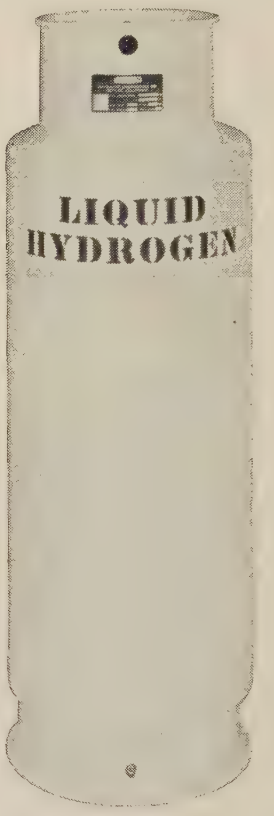
A line of low-noise oscillator klystrons suitable for application in CW illuminators, fixed-frequency Doppler transmitters, and similar systems, has been announced by **Varian Associates, Dept. S/A, 611 Hansen Way, Palo Alto, Calif.**

These model Va-511 klystrons produce 50 watts minimum power at 10 Gc, and operate at 10K volts, 60 ma. This two-cavity oscillator has an FM noise figure of less than 1 cycle, and is electrostatically focused. Weighing less than 24 oz, it measures 6¼ x 2¼ x 1¾ in.

No. 436 on Reader Service Card

CRYOGENICS

new / efficient 175 Liter Liquid Hydrogen Dewar



Here is the first commercial 175 liter liquid hydrogen dewar that eliminates the conventional, cumbersome liquid nitrogen protective shield. A permanent, high vacuum is used in conjunction with Cryenco-Lamina insulation—giving efficient, long storage time, H_2 boil-off is less than 3% per day. Dewar is equipped with fail-safe devices. Price: 1-2—$1473.00; 3-6—$1398.00, each. 20" O.D. x 61½"; tare wt. 180 lbs.; ASME; ICC-4L. For large capacity, convenient handling of (1) H_2 in your laboratory, write for catalog sheet.

RESEARCH AND OPERATIONAL EQUIPMENT

Cryenco manufactures a large line of standard cryogenic "hardware"—the dewar above is an example—also cryovalves, tanks, cold traps, transfer lines, cryostats. Engineered products include He-H_2 refrigerators, purifiers, liquefiers; ground support and flight equipment; accelerator equipment. This equipment is designed to free physicists and engineers for fundamental work. Write for complete catalog.

CRYENCO

CRYOGENIC ENGINEERING COMPANY
222 W. 48TH AVE. • DENVER 16, COLO.
Low Temperature, High Vacuum Equipment and Engineering

No. 239 on Reader Service Card

SIGNAL AMPLIFIER features high gain

A transistorized, high-gain, airborne DC-to-DC signal amplifier has been introduced by **Statham Instruments, Inc., Dept. S/A, 12401 W. Olympic Blvd., Los Angeles 64, Calif.** This SA9-0 amplifier features higher gain, a wider temperature range, smaller size, and excellent stability.

Gain of the unit is continuously variable from 50 to 500, with special models available up to 1000. Operating temperature range from −65 to ±165 deg F. Input is 0 to 10 millivolts DC; output is 0 to 5 volts DC. Power requirements are 30 milliamperes at 28 volts DC. Size is less than 8 cu in., weight is approximately 8 oz.

No. 437 on Reader Service Card

POLARIZED FEED HORNS for reflectors

A series of millimeter switchable linear-circular polarized feed horns have been designed for use with paraboloidal reflectors having a 0.3 f/d ratio. According to **Technical Research Group, Inc., Dept. S/A, 9 Union Square, Somerville, Mass.,** models are available for use at 3.2, 4, and 8.6 mm.

Radiated energy can be switched from linear to circular polarization by rotating a portion of the feed through 45 deg. Axial ratio over a 4 per cent frequency band does not exceed 0.7 db. VSWR is less than 1.3 in either mode.

No. 438 on Reader Service Card

ISOLATOR controls 25,000-v circuits

Circuits at 25,000 volts can now be controlled from ground level through a high voltage isolator developed by **Raytheon Co., Dept. S/A, 55 Chapel St., Newton 58, Mass.** An electro-optical device, this Raysistor consists of a light source and a photosensitive cell contained in a light-proof case. It is encapsulated in a transparent dielectric fluid.

Available in two models, the CK-1105 model requires 120 volts for control, and has a signal resistance of over 10_7 ohms "off" and less than 10_3 ohms "on". The CK-1108 model requires 5 volts for control and has a signal resistance which varies from 10_7 ohms to less than 500 ohms as the control voltage is varied from 0 to 5 volts.

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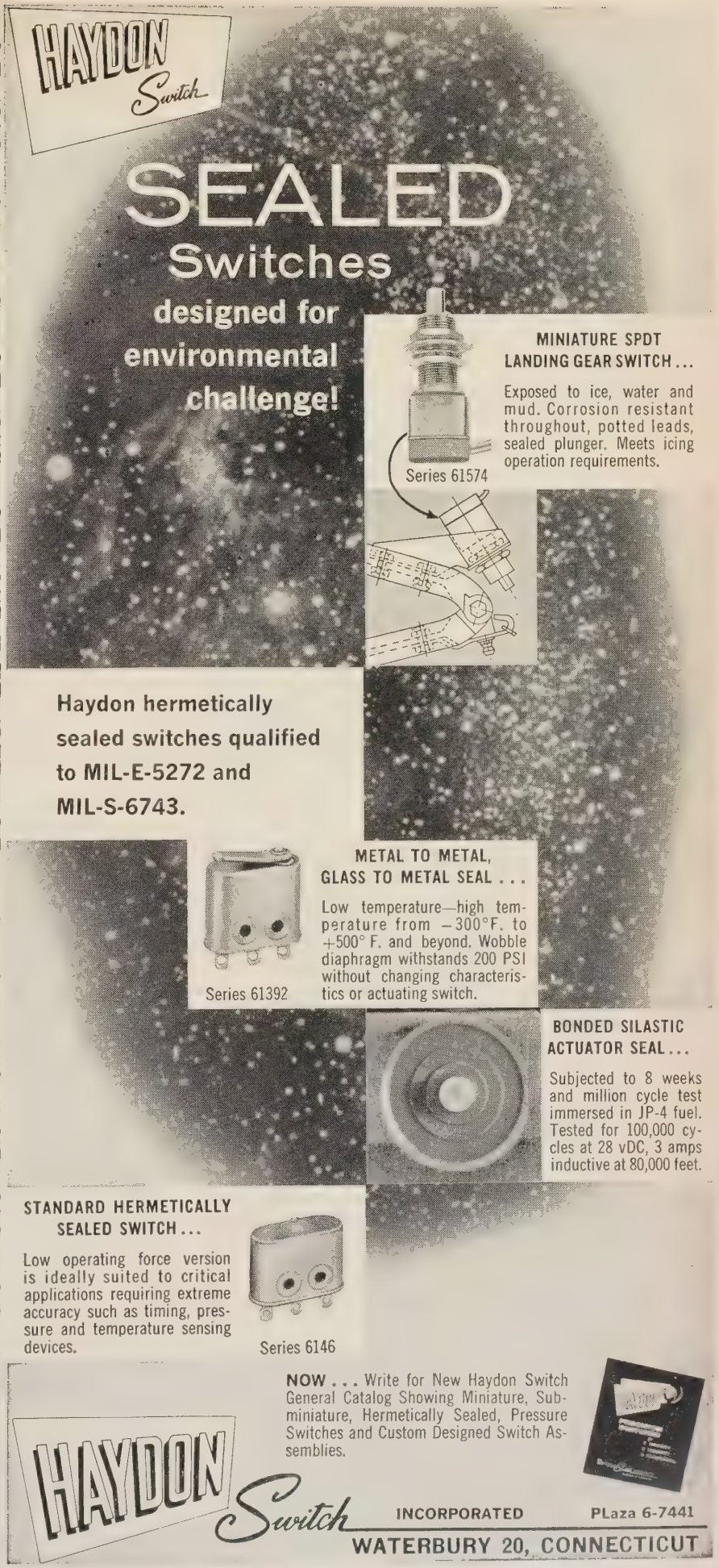
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SEALED
Switches
designed for environmental challenge!
MINIATURE SPDT LANDING GEAR SWITCH...
Exposed to ice, water and mud. Corrosion resistant throughout, potted leads, sealed plunger. Meets icing operation requirements.
Series 61574
Haydon hermetically sealed switches qualified to MIL-E-5272 and MIL-S-6743.
METAL TO METAL, GLASS TO METAL SEAL...
Low temperature—high temperature from −300°F. to +500° F. and beyond. Wobble diaphragm withstands 200 PSI without changing characteristics or actuating switch.
Series 61392
BONDED SILASTIC ACTUATOR SEAL...
Subjected to 8 weeks and million cycle test immersed in JP-4 fuel. Tested for 100,000 cycles at 28 vDC, 3 amps inductive at 80,000 feet.
STANDARD HERMETICALLY SEALED SWITCH...
Low operating force version is ideally suited to critical applications requiring extreme accuracy such as timing, pressure and temperature sensing devices.
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WATERBURY 20, CONNECTICUT
No. 240 on Reader Service Card

THUMBWHEEL SWITCHES

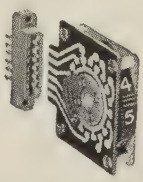
TABET U.S. Patent 2,841,660

Binary & Digital

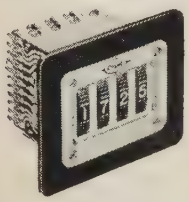
C·D·I

- **For Critical Reliability Applications.**
- **Available with internal lighting MIL-L-25467A.**

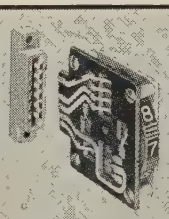
Permanent wafer type, Series TSD-P. Only ½" panel space needed per module. Also available in multi-deck series TM.



Removable wafer type, Series TSD-R. For continuous operation applications where interruptions must be held to an absolute minimum.



Permanent wafer type, Series TSB-P. Available in 8, 10, 12 or 16 positions, up to 36 switches per assembly.



Removable wafer type, Series TSB-R. For applications where maintenance time is valuable and rapid servicing a necessity.

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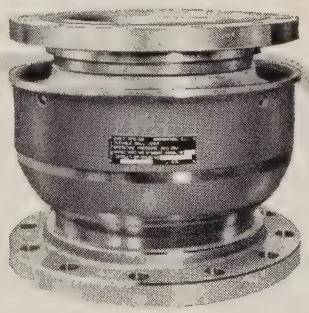

BALL JOINTS— new, lighter weight, flexible—

SIZES: 3", 4", 6", 8", 10", 12"

for **CRYOGENIC** piping

FOR PROJECT REQUIREMENTS—In handling fluid fuels and oxidizers, including liquid oxygen. Also in industrial cryogenics for liquid methane and liquid propane or butane at low, as well as ambient, temperatures.

RECOMMENDED SERVICE—(1) Fluid loading arms. (2) Expansion Joints. (3) Gimbal/Rotary Swivel motion. (4) Shock resistant flexible piping.

NEW, ADVANCED DESIGN—Has passed official "Qualification Tests," including shock tests of more than 100G's. TEMPERATURES: −320°F to +275°F. PRESSURE RATING: Designed for and qualification tested at 200 psi operating, 300 psi proof, 700 psi burst pressures. *Ask for Bulletin 233 B.* BARCO MANUFACTURING CO., 575 F Hough St., Barrington, Illinois.

1st for *SAFETY* BARCO

No. 242 on Reader Service Card

MULTICODER has low power demand

This solid state digital commutator coder can accept data in three forms: multiplexed analogs, serial digital data, and parallel digital data. According to the manufacturer, **Applied Electronics Corp. of New Jersey, Dept. S/A, P. O. Box 43, 22 Center St., Metuchen, N. J.**, the coder has an accuracy of 0.1 per cent variation from input to coded output. The design is one-fifth the size of existing equipment of this type, says the company.

Specification sheets are available for models MCH-3, MCH-6, and MCH-12. Modified special units are also available upon request.

No. 440 on Reader Service Card

HARDWARE for electronic cabinets

Closing, latching, locking, and door-bolting hardware for electronic cabinets adapted from aircraft design hardware are now available, says **Adams Rite Manufacturing Co., Dept. S/A, 540 West Chevy Chase Drive, Glendale 4, Calif.** The designs use mainly stainless steel and aluminum alloys.

Flush latches are designed for horizontal or vertical installation on hinged panels, doors, or drawers. The door-bolting systems secure door seals against the entrance or escape of moisture, dust, air, or other gases.

No. 441 on Reader Service Card

PHOTOELECTRIC TAPE READER uses chopped reflected light

The use of a light chopper wheel and ac coupled amplifiers is featured in this recently developed photo-electric tape reader. According to **Omnitronics, Inc., Dept. S/A, 511 N. Broad St., Philadelphia, Pa.**, this feature assures outstanding stability because the ac amplifier drift characteristics are superior to dc amplifiers. Signal-to-noise ratio is enhanced because the reflected light is used.

The tape reader, model PTR-7, also uses silicon solar cells, solid state amplifiers and power supplies, and simple mechanisms. It reads standard width tapes, up to 8 channels and sprocket of strip or continuous loop tape. Speeds of 10, 30, 75, and 100 ips are available with up to 1000 characters per second reading rate. This 28 lb tape reader measures 19 in. x 12 in. x 5¼ in. Power requirements are 115 volts, 60 cps.

No. 442 on Reader Service Card

CAMERA SYSTEM uses pulse generator

The capability of the Model KSC-51/A Kerr cell instrumentation camera system has been increased significantly by adding a trigger pulse generator to the control unit circuitry, says **Electro-Optical Instruments, Inc., Dept. S/A, 2612 E. Foothill Blvd., Pasadena, Calif.**

The pulse generator permits operation of the KSC-51/A from an external low voltage trigger source, as well as from an internal source. In many applications, the pulse generator can initiate shuttering action directly, without the use of higher voltage trigger pulses. Applications where such triggering actions are adequate include plasma and shock tube studies and hypervelocity and impact phenomena research.

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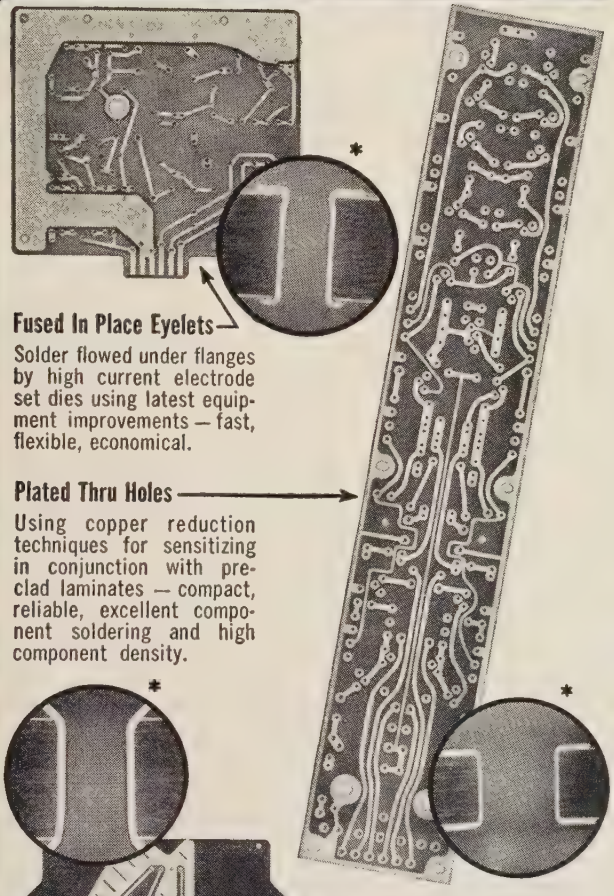
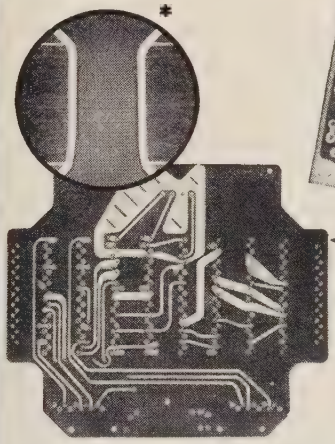
Methode Thru-Connected Printed Wiring Boards

HIGH { Reliability! Re-usability!



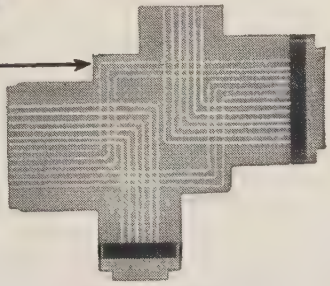
Fused In Place Eyelets
Solder flowed under flanges by high current electrode set dies using latest equipment improvements — fast, flexible, economical.

Plated Thru Holes
Using copper reduction techniques for sensitizing in conjunction with preclad laminates — compact, reliable, excellent component soldering and high component density.



Funnel Tubelets
Funnel shaped tubelets — permit easy component insertion, repeated removal and re-mounting without damage to board or adhesion — maximum reusability.

New Three-Dee Sealed Harness
Methode's new fully encapsulated multi-layer circuitry — permits unlimited cross-overs and taps, flexible, conformal, light and tough for interconnecting individual circuit cards or black boxes.



*37 to one micro photographic cross-section view

Use the Best Prefabricated Wiring Technique for Your Requirement . . .
ALL ARE AVAILABLE FROM:

Methode manufacturing corp.
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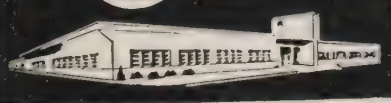
Chicago 31, Ill.



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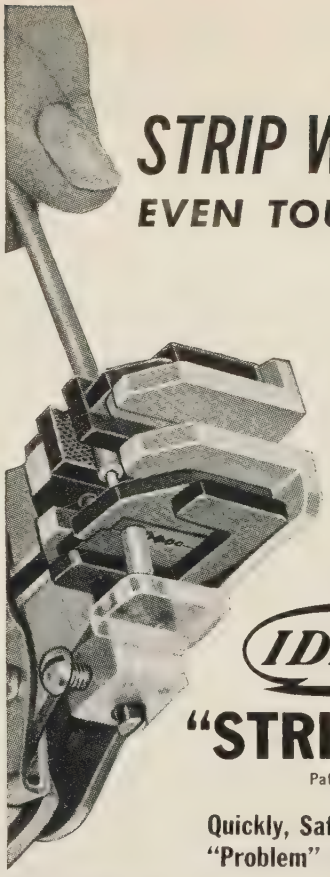

STRIP WIRE FAST-- EVEN TOUGH TEFLON*

WITHOUT A NICK!

IDEAL CUSTOM "STRIPMASTER"
Patented, No. 2,523,936

Quickly, Safely Removes "Problem" Insulation from Wire

Now strip the toughest insulation from any wire with just a gentle, harmless squeeze. With Ideal Custom Stripmaster, matched sets of counterbored blades—*precision drilled on watchmaker's equipment to fit wire sizes exactly* are designed to ride on cut insulation, and eliminate wire nicking and scraping. Firm grip of jaws prevents insulation damage. Wire is stripped absolutely clean up to a full 7/8".

Optional transparent wire stop quickly adjusts so that you strip off the exact amount of insulation you want every time. Perfect for fast, accurate production line stripping.

Custom Stripmasters come in three models for 10 to 14, 16 to 26, or 26 to 30 wire gauges.

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The Custom Stripmaster is just one of a complete line of Ideal strippers including Thermo-Strip and high-speed electrically powered models for every insulation-removal need. WRITE FOR NEW WIRE STRIPPER BROCHURE.

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1435-J Park Ave., Sycamore, Ill.
Please send me a copy of your new WIRE STRIPPER BROCHURE

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TELEMETRY—Five equipments for airborne telemetry systems are described in a 60 page data sheet published by **Vitro Electronics, Dept. S/A, 919 Jesup-Blair Drive, Silver Spring, Md.** The data sheet describes an FM phase-lock telemetry receiver, a preamplifier, and a multicoupler for up to eight receivers.

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WAVEGUIDE CHART—A cross reference chart that covers all standard EIA waveguides from WRIO to WR-2300 has been prepared by **Microwave Development Laboratories, Inc., Dept. S/A, 15 Strathmore Rd., Natick, Mass.** The chart includes data on electrical performance and mechanical dimensions.

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ANTENNA—A booklet of engineering data on the Model 3001 s-band antenna is available from **Adams-Russell Co., Inc., Dept. S/A, 200 Sixth St., Cambridge 42, Mass.** It is illustrated with diagrams, photographs, and graphs.

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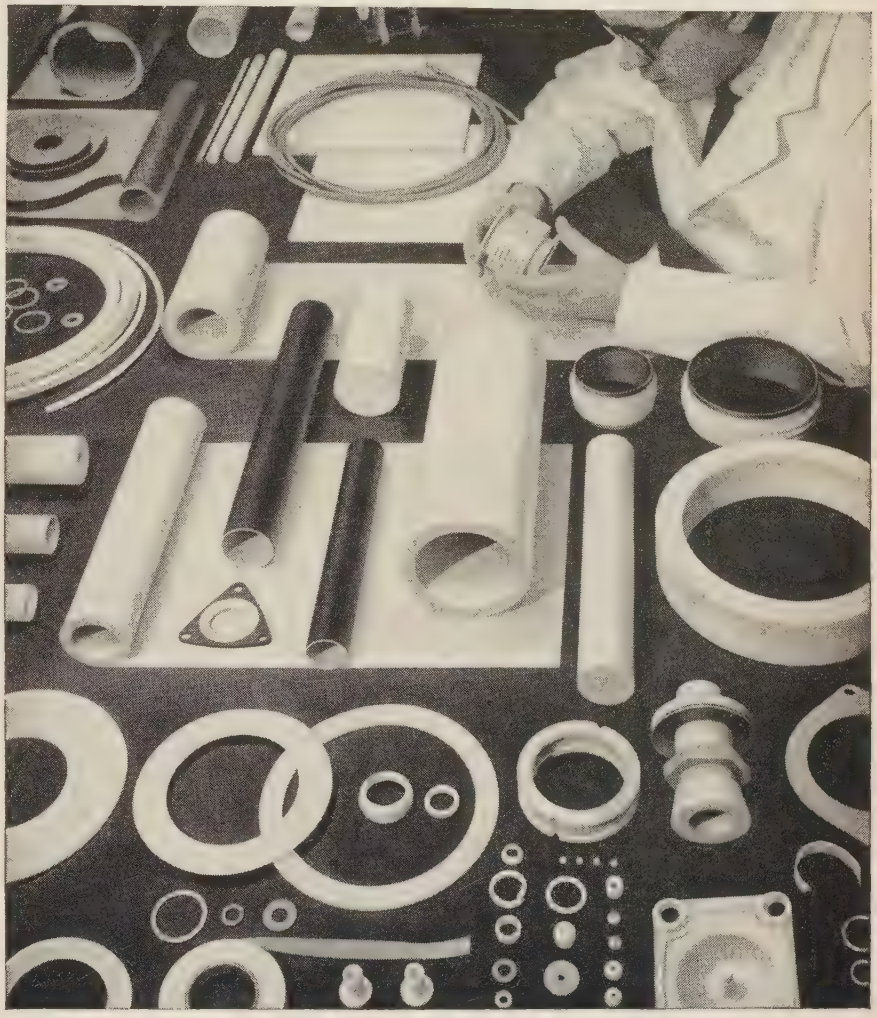

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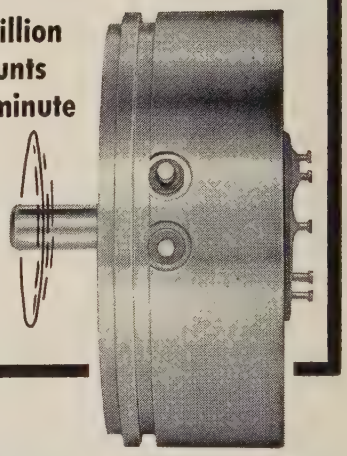

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News of materials for the aerospace industry – selected from the 27,000 products of the 3M Company

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SEVEN LEAGUE OPTICS

Though the fact is almost eclipsed by the staggering impact of the pizza pie, sunny Italy has in its day made another small contribution or two to this world's technology. Tucked away in the annals of history we find the account of a bright young lad of Pisa called Galileo. Telescope making was one of his specialties. We think he did a first rate job under the circumstances – but telescopic optics have come a long way since then. There's been the Newtonian system; the Cassegrain; the Gregorian; the Schmidt – and finally the fully corrected catadioptric telephoto objective, a product made by the Wollensak Optical Company (now part of the 3M family), and sold under the trade-mark "Mirrotel".

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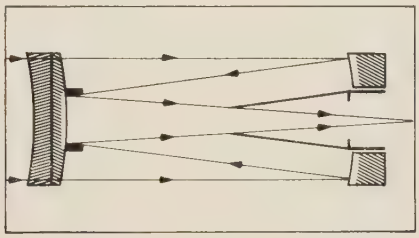

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Why engineers change jobs

THE 134 ENGINEERS in this month's Readers' Round Table range in age from 23 to 71, in years in engineering from 1 to 51, and in salary from $6400 to $24,000 a year. All but 13 are married, and all but a handful of the married men have children.

The "average" member of the panel is 35.7 years old, and has been an engineer for 9.7 years. He has held 2.9 jobs during his engineering career, has been at his present job for 6.4 years, and is making about $11,500 a year.

If he leaves his present job, he says, he'll be looking for more challenging work and more responsibility first, higher salary second. But he thinks most of his fellow engineers rate money higher than challenge.

Money talks—but how loud? As a matter of fact, the correlation between an engineer's restlessness and the size of his paycheck seems to be only moderately high. Over half the engineers in our survey—78 men—are satisfied with their present salaries, and 31 of these 78, or 38 per cent, are thinking of changing jobs anyway. Of the 53 who are not satisfied with their present

Q. Age?
A. Under 30: 18; 30-39: 77; 40-49: 29; 50 and over: 10

Q. Years in engineering?
A. 5 or less: 19; 6-10: 46; 11-15: 40; 16-20: 16; 21-25: 9; over 25: 4

Q. Engineering jobs held?
A. 1: 27; 2: 36; 3: 30; 4: 13; 5: 12; over 5: 16

Q. Years in present job?
A. 1 or less: 19; 2-5: 51; 6-10: 46; 11-15: 12; 15-20: 5; over 20: 1

Q. Yearly salary?
A. $6000/7999: 12; $8000/9999: 26; $10,000/-11,999: 25; $12,000/13,999: 29; $14,000/-15,999: 23; $16,000/19,999: 8; $20,000 and over: 6

Q. Do you feel that your present salary is approximately what you and your present job are worth?
A. Yes: 78; no: 53

Q. Are you, right now, definitely decided on, or thinking about, leaving your present job?
A. Decided: 9; thinking: 50; no to both: 75

Q. Do you think it's likely that you'll still be with your present company five years from now?
A. Yes: 72; no: 37

Q. Would you change jobs primarily for a higher salary?
A. Yes: 25; no: 109

Q. Would you feel that you could take a salary cut for a new job that looked really good and offered a good chance for advancement?
A. Yes: 76; no: 58

Q. Would getting a supervisory position with your present company make you more inclined to stay there?
A. Yes: 40; no: 41

Q. If you're already a supervisor, do you think you're less likely to leave than you were before you became one?
A. Yes: 30; no: 19

Q. Would you like to go into business for yourself?
A. Yes: 69; no: 61

Q. Would you take a cut in income to do so?
A. Yes: 56; no: 13

Q. Do you have any serious plans for starting your own business?
A. Yes: 14; no: 55

Q. What do you estimate is the annual turnover of engineers in your company?
A. Under 5%: 32; 5-10%: 50; 11-15%: 13; 16-20%: 12; 21-25%: 7; over 25%: 7

salaries (including two who think they are overpaid), 27—or just over 50 per cent—are thinking of moving.

An 80 per cent majority (109 of 134) says that they would not change jobs primarily for a higher salary. The 25 men who say they would, however, refuse to admit that they're in the minority. "Anybody would go anywhere for enough money—even to the East or South," says one Californian. On the average, they'd move for a 20 per cent raise.

A smaller majority, but still more than half (76 men) say that they would take a salary cut (average size, 10 per cent) for a really good new job. (Many of them emphasize that the job would have to be very good indeed.)

"Salary has numbers" The feelings of the 58 who say they wouldn't risk a cut are best summed up by the engineers who comment, "Any new job is full of uncertainties—salary has numbers," and "This is an old dodge by many companies to obtain new men." Several say that they regret having taken cuts when they went to their present jobs, and a few are positively indignant at the idea—"contrary to principles and considered most ill-advised."

The only engineers who feel really bitter about their financial status are the men in their late twenties who are still in the lowest salary bracket and see "new graduates hiring in for more than I'm making."

Eighty engineers in non-supervisory positions are split almost exactly 50-50 on whether or not they'd be more likely to stay with their companies if they got supervisory jobs. ("Supervision is desperately needed—I think I would be an improvement," says one of the 40 who would.)

Supervision vs creativity Some of the 41 who say "no" are so dissatisfied with their companies that they wouldn't stay on any terms. But more of them just don't want to be supervisors. They believe that administrative work would inevitably take them away from creative engineering.

Their comments range from a mild "I'd rather advance in the more technical positions" to "I believe I would resign if I were forced into a supervisory position. Leave that to the business administration majors and lazy engineers."

If a man does want a supervisory job, he'll probably —but not certainly—be less restless after he gets one. Thirty of 49 supervisors on various levels say they're more likely to stay with their companies than they were before they got promoted. But the remaining 19 indicate that they'll stay only as long as the promotions keep coming. (Two are bucking for vice presidencies.)

When do they settle down? Engineers don't seem to lose their mobility as they get older. Almost half of the men in their forties, as compared with exactly half of the men in their twenties, are thinking about changing jobs. (If a man in his forties does like his job, though, he's more likely than a younger man to plan on being there five years from now.)

Slightly more than half of the respondents say they'd like to start a business of their own, and the number who say they're making serious plans to do so—14, or a little better than one in 10—seems fairly impressive.

Most of those who say they'd like to but aren't making plans cite "money (lack of)" as their reason. "Inertia" and "no guts, I guess" are close seconds.

The open-end question that wound up the questionnaire, "What do you think your company could do to keep more of its engineers?", produced a flood of brainstorming from which half a dozen major points emerged.

"Get more contracts" "New R&D contracts for more challenge". . ."get more work of interesting nature". . . "get more business". . ."more challenging work, and more work!" This was constantly recurring refrain—if you want to keep your engineers, keep them busy engineering.

The same note was sounded by several men in comments on why they may leave their present jobs: "Thinking about leaving due to lack of contracts and interesting problems". . ."engineering workload here is practically zero—many opportunities exist elsewhere with interesting and challenging assignments". . ."my company's success in my particular field of interest will decidedly influence how long I remain."

"Get better management" This comment, too, was repeated over and over. "Provide long range planning and eliminate helter-skelter turmoil". . ."Stop growing like Topsy and start planning". . ."The company should know what it wants to do, formulate a definite set of goals, and then allow the technically competent people to carry them out. The biggest problem is that management doesn't know where they are going (and this, presumably, is what they are getting paid for.)" Pride in the company's reputation is important: "My company should recover the industry leadership it once held."

Here again, men who are planning on leaving their jobs made similar comments: "If they don't shape up, I'm shipping out."

Better supervisors, too "Better engineering supervisors at the working level" was a third refrain. "Just hire one chief engineer who really knows his job". . ."Require supervisors to possess some executive ability."

One engineer wrote: "My department head has an A&E ticket—that's all, you judge it. He has no background, no leadership. He has his position solely through politics. He can only criticize small things; major items he has no opinion on, as he actually has no technical feeling for them."

The importance of plant politics ("promotions based on buddyship". . ."car pool managers") is an annoyance to a good many engineers. Only one of the 134 seemed to see himself as something of a politician: "I'm pretty well bedded down here, and recognized in the plant as an 'inner circle man'."

"Give engineers more professional respect . . ." is the fourth of the frequently repeated suggestions. Professional respect is, of course, to some extent intangible; but the Readers' Round Table engineers seem to feel it could be shown by:

- granting of authority to match responsibility;
- permitting "more individual creative engineering without close controls";
- reduction of non-engineering paperwork;
- elimination of petty regulations and restrictions.

("It's the damn attitude," says one engineer. "Although we are cleared for secret, we still must open lunch boxes coming in and going out.")

Who gives the raises? Next comes, "take a sincere rather than a perfunctory interest in the paramount problem of the individual engineer—his progress." Usually, this seems to mean a well-administered system of merit raises and promotions, and special rewards for outstanding accomplishments. ("As a run-of-the-mill en-

What Matters about Engineering Jobs?

The Readers' Round Table questionnaire included listings of 14 causes of job dissatisfaction and nine factors an engineer might consider when evaluating a prospective new job. Respondents were asked to indicate by number (1 for most important, etc.) how important each item is to them personally and, in a second column, how important they thought each item is to other engineers. They were told to give the same number to any two or more items that they rated as about equally important, and no number to any that struck them as unimportant.

The lists are reproduced here, showing, for each item, the number of "most important" mentions it received.

The relative standings of salary, advancement, and challenging work in the two columns indicate that most Readers' Round Table respondents consider themselves to be a little more high minded than most engineers.

In total number of mentions, without consideration of numerical values, salary came in first in both columns on the "Job Dissatisfaction" chart, with challenge a close second. "Advancement in rank" and "financial advancement" were third and fourth under "Importance to You," fourth and third under "Importance to Others."

Virtually all the respondents checked these four items, and most assigned them numerical values of 1 through 4.

Under "Importance to You," the next three highest mention totals went to "too much red tape and routine," "dissatisfaction with company's attitude toward engineers," and "lack of professional respect for supervisors." Under "Importance to Others," the next three highest were "being passed over for promotion," "excessive supervision," and "too much red tape and routine."

On the "Prospective New Job" chart, under "Importance to You," challenge and responsibility were tied for first place in total number of mentions, with salary third and "favorable impression of company's attitude toward engineers" fourth. Under "Importance to Others," salary came in first, with challenge, responsibility, and "favorable impression of company's attitude toward engineers" in the next three slots.

Reasons for Job Dissatisfaction

	Times mentioned as "Most Important"	
	Importance to You	Importance to Others
Lack of interest or challenge in work	58	48
Responsibility, rank, etc.	47	24
Salary	19	47
Poor prospects for financial advancement	19	23
Dissatisfaction with geographical area or community for personal or family reasons	12	7
Being passed over for promotion	11	8
Lack of professional respect for supervisor(s)	7	7
Excessive supervision	5	6
Dissatisfaction with company's attitude toward engineers	4	4
Too much red tape and routine	3	1
Lack of professional respect for co-workers	2	3
Dissatisfaction with physical working conditions	2	1
Dissatisfaction with fringe benefits, etc.	1	2

Factors To Consider in Evaluating a Prospective New Job

	Times mentioned as "Most Important"	
	Importance to You	Importance to Others
More interesting and challenging work	81	34
Higher level of responsibility	36	20
Higher salary	25	60
Small, new company	11	6
Geographical location and community (desirability of housing, schools, recreational facilities, etc.)	11	2
Relative freedom from supervision	10	4
Attitude toward engineers	9	6
Better working conditions	4	5
Better fringe benefits	1	3

gineer, at 49, I find that work appraisal and merit rating is often done by supervisors who are not even acquainted with what their peons are doing," one man says.)

Finally, companies who want to keep their engineers should "keep them better informed of company activities and general goals." "Closer relationship between management and engineers would produce a spirit of teamwork and satisfaction". . ."more effective communication between management and employees". . ."better publicity for company benefits" are typical suggestions.

Several men mention better working conditions ("Improve engineering office and lab facilities—QUIET!"). Other ideas run the gamut from "more company funded research projects" and "in-plant seminars in each major field" to "offer third week of vacation after five years" and "institute coffee periods."

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and muscle mechanisms
to take just the right action—
even if it amounts only to
wiggling his toes
in his sneakers.

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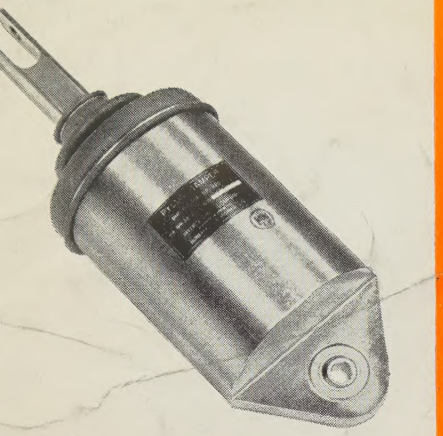

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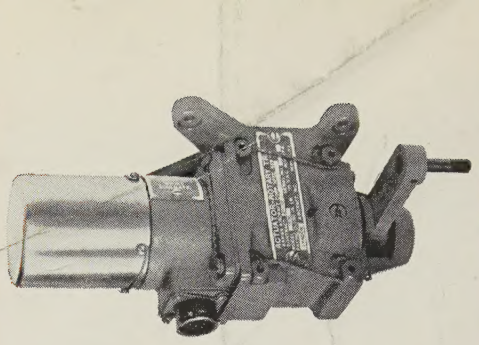

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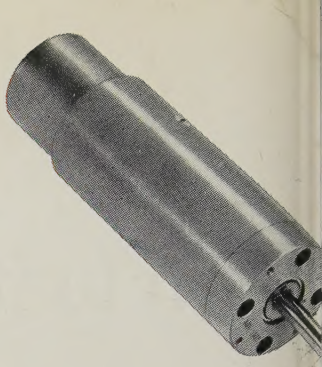

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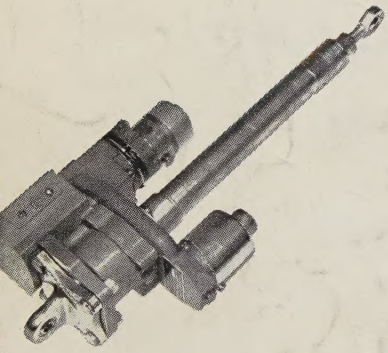
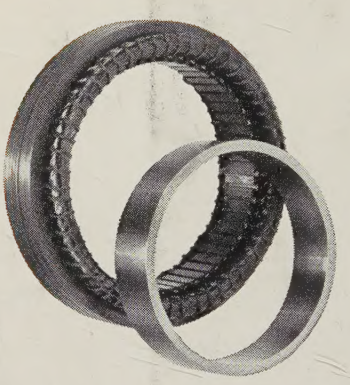


LINEAR ACTUATOR



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